Study 'Roaming data services'

Authors: Erik Vrolijk & Raymond Bouwman

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Summary

Current Situation

Currently, mobile roaming data rates are not subject to regulation. The Regulation of the European Parliament and of the Council on roaming on public mobile networks within the Community and amending Directive 2002/21/EC relates to voice telephony. However, this Regulation stipulates that the European Commission should review the functioning of the Regulation and report to the European Parliament and the Council. The Commission must review the developments in wholesale and retail charges for the provision to roaming customers of voice and data communication services, including SMS and MMS, and shall, if appropriate, give recommendations regarding the need to regulate these services.

Purpose of the Study

The Commission requested a study containing a factual description of the market for both wholesale and retail data roaming as part of its obligations under the Roaming Regulation. This study will serve as input for the Commission in reaching a decision concerning regulation of data roaming services. This study analyses the topics of data and data roaming from different perspectives:

- The technology and service perspective

- The retail market perspective for mobile data services

- The wholesale market perspective for data roaming services

- The cost perspective for data roaming services compared to national data services

Based on the abovementioned analysis from the different perspectives it is important to understand how wholesale roaming charges have an effect on retail roaming charges and the pricing issues that exist in the market as a result of this.

The Technology and Service Perspective

Technology Roadmap

In Europe the major developments and implementations of mobile communication relate back to the launch of the Global System for Mobile Communication (GSM) in 1992. GSM became extremely successful and has evolved into an ad-hoc world standard for mobile communication. GSM was developed primarily to support voice services, although at an early stage messaging (SMS) and circuit-switched data services were available. After the standardization for GSM had been completed, new technologies were standardised such as General Packet Radio Service (GPRS), Enhanced Data rates for Global Evolution (EDGE) Universal Mobile Telecommunication system (UMTS) and High Speed Data Access (HSPA)

The roadmap for GSM and HSPA has also been adopted in many parts of the world outside of Europe, although there are alternative radio network technologies available such as Wi-Fi, WiMAX and EV-DO

Data Packet Services

HSPA clearly makes the difference for the telecommunications industry in launching mobile data and meeting its business targets. HSPA has evoked a significant improvement in data rates for both downlink speeds (High Speed Downlink Packet Access, HSDPA) as well as uplink speeds (High Speed Uplink Packet Access, HSUPA). Additional improvements due to HSPA are a better spectral efficiency (amount of data per unit of frequency) and shorter delay time (latency) for data transfer.

Currently mobile operators in Europe commonly apply GPRS, EDGE, UMTS and HSPA technology to offer packet data services. Most operators, if not all, have decided for a 'home roaming' implementation of data services, meaning that both the visited and the home network are required for a roaming data session. Home roaming implementation has several advantages such as: service platform connectivity in the home network, billing, real time charging, prevention of fraud etc. In the case of home roaming, the SGSN in the visited network and the GGSN in the home network need to be interconnected. The most common solution for this interconnection is the use of a GPRS Roaming Exchange (GRX).

User Data Services

The bearer technology for packet switched networks such as HSPA is used for several different data services. This distinguishes HSPA enabled data services from voice and SMS, in which there is basically 1 service to 1 bearer technology. Some examples of end user data services are: Mobile Internet Access, Messaging Services (Email, MMS etc.), Entertainment (including Mobile TV), M-commerce (e.g. banking), Machine-to-machine services, Mobile office, and voice (VoIP, Skype etc.). The emergence of improved services as a result of HSPA technology may vary depending on the type of service. Some existing services are unaffected (e.g. SMS or low-bandwidth data services such as text email), other services will show improved user experience e.g. file download or internet browsing. In addition, some entirely new services are enabled by HSPA (e.g. video/audio streaming, Mobile TV). The improvement of latency is leading to the uptake of voice and video calling services using internet capabilities.

The retail market perspective for mobile data services

The 'managed model' versus the 'unmanaged model'

For mobile data services, the mobile industry distinguishes 2 concepts: the 'managed' and the 'unmanaged' model. The concept of the 'unmanaged' model is similar to what is offered by fixed line broadband providers. In general basic fixed line internet access is provided (often differentiated on transmission speed) without distinguishing the different services that can be used over the internet. Customers pay a flat fee per month. The internet services are offered by parties such as MSN, Skype, and Google etc. If applicable, the customer directly pays for service usage to the provider of these services, and not through the fixed broadband provider. The mobile industry also offers this type of 'unmanaged' service in which a customer usually pays a flat fee per month for a certain data volume.

In addition to this 'unmanaged' service, mobile operators offer 'managed' services. Examples of these services are: Blackberry, MMS, Messaging, Mobile TV, Machine to Machine services, etc. These are offered as a complete service to the customer in which basic infrastructure, service specific infrastructure (like for instance the MMS platform), software, quality of service, devices,

and price plans are combined in one integrated offer to the customer. The mobile operator then has 'full customer ownership' meaning that the mobile operator invoices for both the internet access and for the service offered.

These 'managed' services are an essential component in the business model that mobile operators use in the mobile data market.

Service based pricing

The various data services offered in the 'managed' model on the packet switched bearer technology are priced differently. Data traffic can have a different price per MB depending on the service in which it is packaged.

The spread in the per MB rates for the different services is substantially more extensive than the variation occurring in price per minute for voice in, for instance, the different segments. This price differentiation is driven by the value perceived by the customer for the service rendered, the cost components needed for constructing the service, and the competitive situation.

In general, services that require high volumes of data have a lower average price per MB. When considering whether data services should be regulated it is important to take into account the fact that the price per MB to the retail customer may vary in accordance with a number of factors.

Market situation for national data usage

The mobile data market has certain characteristics that cause operators to move to an aggressive price approach on national mobile data services:

- Mobile data are an emerging market. Customers need to get familiar with the possibilities and benefits of mobile data

- Operators in some cases are faced with excess capacity on the data networks

- HSPA technology creates the possibility to compete with fixed ADSL networks

- Costs for data networks have a 'shared' nature. For instance, there is no data volume interconnect charging for mobile data services. For voice, the interconnect charges create a bottom line (base) for the retail charges. For mobile data such a threshold does not exist

Price levels national data usage

Taking into account the concept of the 'managed' model, the principle of service based pricing and the market situation, several trends in retail mobile data pricing can be distinguished.

Data services are often offered in a bundle with a monthly fee. This applies to services like web browsing, Blackberry and PDA/smart phone web/e-mail access.

Basic mobile access to the internet is offered at aggressive rates competing with fixed ADSL in some cases. In the highest national bundles the price per MB can be below € 0,01 per MB when the total bundle is consumed. In some cases, unlimited usage is offered. This development is mainly driven by the increased capacity and increased transmission speeds because of the migration to HSPA technology over the past 1-2 years.

In addition to this general downward trend there is also a high differentiation in prices per MB for the different data services. An MMS of 20 KB priced at € 0,50 per MMS has an equivalent

price per MB of € 25,00 per MB. An SMS sent via the packet switched network of 3 KB priced at € 0,10 has an equivalent price per MB of € 34,00. For some machine to machine solutions with low traffic volumes the average rate per MB might even be higher. On the other hand, there are MB rates below € 0,01 in large volume bundles with multiple Gigabytes included.

The abovementioned developments have, led to a substantial increase of mobile data volumes and revenues over the past 1-2 years.

In case operators want to extend the abovementioned downward pricing trend in national data usage (including the further differentiation) into their retail data roaming offers, this requires changes in the wholesale data roaming rates agreed between mobile operators.

Future sustainability of current retail offers

It remains to be seen if some of the current offers are sustainable from a cost perspective in the long run. Current retail offers do not necessarily reflect historic and/or future cost levels for mobile data networks.

In addition to the fact that making relevant and objective cost calculations for data is difficult, relatively little experience has been gained with data service cost pricing in comparison to experience gained with cost pricing for voice

Current offers could attract substantial numbers of new customers using mobile broadband as an alternative to fixed ADSL. This might lead to a situation in which operators will have to expand the capacity. The cost for this expansion of capacity for some operators might conflict with the revenues generated by mobile data. Some operators might be forced to change certain offers.

From a retail market perspective the data roaming rates can be benchmarked against the national mobile data rates. This will also be the point of view of the retail customer. However, from a cost perspective the national data roaming rates might not be the right level to benchmark against when evaluating the current wholesale and retail data roaming charges.

Wholesale data roaming perspective

Business process for data roaming

Data roaming is an add-on to national data service and to the voice roaming service. It requires:

- Additions to the general roaming contract
- Determination of a Inter Operator Tariff
- Roaming negotiations to agree on an improved inter-operator tariff (IOT)
- Network and billing facilities
- Testing and roll out

IOT and wholesale negotiations

There are 2 models for the standard Inter Operator Tariff for data usage:

1. Flat rate per MB combined with billing increments. A wide variation in increments is seen in the market. Some operators charge on a per KB basis, while others have a first increment of for instance 100KB

2. 'Step based' pricing per MB in which the volume of a data session is divided in steps that are rated at different rates per step. In general, high volume sessions are priced at lower rates. This type of wholesale charging comes close to the service based charging for the retail data service

In Europe it is estimated that in 2007 the average (for all data volume exchanged) standard IOT charged for data roaming varies between approximately € 5,00 and € 10,00 per MB. This not only depends on the MB price per MB but also on the data traffic profiles. Because of the increment charges, operators with larger volumes of high speed (laptop) data sessions may have lower IOT levels than operators which have smaller volumes of high speed data sessions.

Negotiations on data wholesale rates are part of the negotiations for all roaming volumes. Data rates are negotiated with first preferred roaming partners for voice traffic. Because the first preferred partner might not offer a network with sufficient speed and capacity (not all networks offer UMTS/HSPA) and because the rate differences between preferred and non-preferred partners are substantial (reaching up to ratios of 1:20), there is now an apparent trend that negotiations for lower data wholesale rates also take place between non-preferred partners.

Up until 2007, the negotiated IOT was usually a flat rate per MB, billed per KB. In general, in the negotiated wholesale rate there is no differentiation between services or data volumes (as is made for data offers in the retail market). In this sense, the wholesale roaming negotiations are not 'connected' to the need, of the retail marketing departments for lower rates on sessions with large data volumes.

For 2007 it is estimated that between preferred partners the level of the negotiated IOT is typically between € 0,50 and €1,00. In exceptional cases, the negotiated IOT may be below € 0,50. The rate of € 0,25 that has been announced by the Mobile Challengers Group is an example of this. With non-preferred partners it may be difficult to agree on a low IOT for data, because of the limited roaming volumes (voice and data) exchanged. However, Vodafone announced in 2007 that its wholesale offer of € 0,50 is applicable to all operators as long as it is agreed on a reciprocal basis.

Within groups of operators wholesale rates are agreed amongst each other. Different groups can have different rules for determining these intra-company rates.

As of 2008, some operators are moving to a discounted IOT based on the 'step price' model. This enables the home operator to offer more attractive retail rates for larger data sessions.

Traffic steering

Traffic steering for data traffic is needed in order to make sure that the customer is being served on the network that provides sufficient transmission speed for the different data services and is also important to bring down the average rate paid for data services in a country.

Traffic steering for data traffic can be less effective than for voice traffic. Steering has been implemented by mobile operators primarily from a voice perspective in order to reduce wholesale (roaming) costs, improve margins, or optimize roaming retail rates. For data services some new challenges are apparent for steering of roaming. The preferred network for voice roaming is not necessarily the preferred network for data roaming if this data network has an incompatible technology, does not offer the appropriate Quality of Service (e.g. if UMTS or HSDPA are not available to the roamer). As a result, if steering of roaming is voice-driven, a handset (laptop, blackberry, PDA) may be steered to a wrong network.

The cost perspective for data roaming

Incremental Cost component model

In the study a cost component model for roaming is presented that summarizes areas of incremental costs. These areas are:

- Extension of components in the existing roaming inter-operator process

- New components for the roaming inter-operator process

- New components (Home Operator)

- Extension of existing components (Home Operator)

- New components (Roaming Operator)

- Extension of existing components (Roaming Operator)

The cost components could be network elements, systems, processes etc. In mapping these cost components it is concluded that there is a limited number of new components when compared to the already existing voice roaming service. In implementing data roaming many of the existing components for voice roaming need to be extended or updated

Incremental Cost Analysis

When evaluating cost levels, it is important to be aware that cost level is only one of the factors that operators consider when constructing a retail data offer. Next to costs there are elements like packaging, segmentation, transparency, service based pricing, and market situation that might prove to be more important drivers for constructing a data offer at this stage of market development.

From the perspective of the home operator, the cost components used for providing national data service are also used for providing roaming data service. The main difference between national and roaming data is that some of the components (e.g. the radio network and the SGSN) for data roaming are used in the visited network instead of in the home network.

It should be noted that additional radio or core network capacity is required if large amounts of roaming data sessions take place. This, of course, has a considerable cost, but it does not necessarily lead to costs different than adding radio or core network capacity for national data services. When using these similar components as for a national data service, a cost increment in the cost price for data service can be justified if:

- Traffic profiles for the roaming traffic differ from the traffic profile for national data services. For example there may be seasonal differences due to tourist concentrations in certain locations. In those locations there could be overcapacity in the radio network outside the tourist season. This may have a cost increasing effect for the mobile operator.

- The unit costs for the components explored from the visited network are different from the unit costs for these components in the home network. This could be caused by a difference in supplier, technology, or traffic volume.

These differences in cost could contribute to a difference in the Inter Operator Tariff (IOT) that the home network has to pay for. If the IOT were higher this could lead to a higher retail price for the roaming data service.

Besides the fact that for roaming data service similar cost components are explored for providing the service, there are additional costs involved to enable data roaming on top of the voice roaming service. These costs concern:

- One-time costs in the home components to enable data roaming

- One-time costs for changes in existing roaming processes and components

- One-time cost for new roaming processes and components needed for data roaming

- Recurring costs in existing and new roaming processes and components

The new component needed to enable data roaming is the GRX service. The cost for GRX-service is expected to be between € 5.000 and € 10.000 per month, depending on the size of the operator. In mapping cost components it is concluded that there is a limited number of new components with respect to the already existing voice roaming service.

In general, the total one-time costs are not expected to be substantially different for small or large operators. This is also expected to apply to some of the recurring costs.

Over time when data volumes will be increasing, the cost per traffic unit may be expected to decrease significantly, since total cost increments are only partly volume dependent. Recurring cost increments are expected to increase proportionally but at a low rate. Verification of this expectation needs further study.

The cost price per MB - for the abovementioned additional components needed to provide data roaming service- depends highly on the volume.

Currently, at low data volumes, incremental cost levels for roaming data are expected to be determined primarily by one-time implementation costs for data roaming services.

In a low data volume scenario, the cost price per unit of traffic may be substantial compared to national data. This could justify an increment for the retail rates of data roaming compared to the national data rates. It needs to be noted that such an approach can also limit the future growth of data roaming volumes.

In a high data volume scenario (for large operators and/or at substantial market growth) and after depreciation of the one-time costs for data roaming implementation, the cost price is expected to be substantially lower than the current cost price for roaming data. Verification of this expectation needs further study.

Small operators may have a relatively high incremental cost, caused by low data volumes and by them having one-time incremental costs that are nearly equal to those of large operators. Even at higher data volumes small operators may have difficulty in reaching the same incremental cost levels as large mobile operators.

Determination of the actual levels of the cost increments in the various situations for different operator scenarios is outside the scope of this study.

Translating the wholesale data rates to a retail data roaming offer

For national data services the majority of costs are of a 'shared' nature. However, for roaming usage there is the substantial component of the wholesale charge that needs to be paid to the visited operator. Just as interconnect rates form the "base' for voice rates, the agreed wholesale roaming rates are the 'base' for retail data roaming rates.

Most operators have changed to network and country independent (for countries within the EU) retail pricing for both voice and data services for their roaming traffic. This means that the average wholesale charge agreed within Europe forms the basis for the retail offer for data roaming in Europe, not the charges agreed with the individual operators or the charges for certain countries.

Retail prices for national data traffic (for large volume bundles) falling to levels of a couple of eurocents per MB (or even below) combined with an estimated (for 2007) average negotiated wholesale roaming charge for the European region between € 2,50 and € 5,00 (depending on the region, the networks used, the effectiveness of traffic steering, the volume characteristics and the negotiation power), demonstrates the difficulty for some operators to offer attractive retail data roaming prices to the market for high volume data sessions like web access. For other types of usage – like Blackberry, requiring smaller data volumes and having a higher national data rate - this is a non-existent issue. Using 200 KB of data a day on a Blackberry device at a retail roaming rate of € 5,00 per MB, translates into an average daily cost for the customer of € 1,00.

In particular for small operators or small operator groups in a net paying position this will be difficult because they have limited possibilities to negotiate data roaming rates and/or 'internalize' wholesale charges. For large operator groups with a large footprint in all major destinations (in which they offer HSPA based technology) the wholesale charges will be less of an issue in constructing attractive retail data roaming offers. When wholesale charges are 'internalised' group members will only have to take into account the actual cost involved in data roaming and they will be able to offer data roaming services at levels closer to the national data rates. Although groups have these possibilities, because of cost involved in setting up data roaming, competition and/or value offered to the customer, data roaming is not automatically offered at rates close to national rates.

The model most often seen for retail data roaming charges is a price per MB combined with billing increments. The average retail charge in the EC is at € 5,24 per MB in Q3 2007 (source ERG data). In some cases, the rates are different per segments or per service.

Operators are now moving to offer monthly or daily bundles of roaming data volumes. For these bundles the retail data roaming price could be at a level below € 1,00 per MB, whereas for non-bundle usage the rates typically range between € 5,00 and € 10,00 per MB. For Business users paying € 0,02 per MB in a national bundle and € 1,00 per MB in a roaming bundle, the ratio is 1:50. Even combined with the Vodafone daily 50 MB bundle the ratio would be 1:12 if the bundle is fully used.

Bundles with unlimited usage (combined with a fair use policy) for data roaming are not often seen. In some cases, operators offer this for roaming with Blackberry; this can be done because the volumes are small and predictable. For a service like web browsing, operators do not offer this because of the wholesale rates that need to be paid per MB to the visited operator. In general, the home operator is not willing to take this risk because of the potentially high volumes combined with high wholesale rates.

Issues in the market for data roaming

Based on the above it can be concluded that for some operators it is difficult to construct attractive data roaming offers for services that require high data volumes. The main reasons for this are:

1. Customer expectations based on national data rates:

- The national data are usually offered in large bundles. This leads to a high predictability of monthly cost for data usage

- The price for national data usage for high data volumes is at an aggressive rate of a couple of Eurocents or even lower

2. Wholesale charges for data roaming:

- Home operators are faced with wholesale charges per MB for roaming usage

- Wholesale roaming data rates are often at a flat rate per MB and not differentiated per service

- Wholesale roaming rates can vary substantially between preferred and non-preferred partners

3. Traffic steering for data might be less effective than for voice leading to a higher average wholesale rate per MB for a certain country

4. Operators prefer country and network independent retail prices

The relatively high data roaming rates for high volume data sessions combined with customers that are often not aware of their price plan for data roaming and of the data volumes used abroad can lead to customers being unpleasantly surprised when returning home and receiving their bill. This has caused customers to be very cautious about data roaming, resulting in low data roaming volumes so far.

Market solutions

Mobile operators consider the current market situation a problem. Customers are unsatisfied because of shock bills and volumes and revenues are low. Over the past year operators have started to move to the following solutions:

- Increased focus on data roaming negotiations targeting on lower wholesale rates, with both preferred and non-preferred partners, service and volume differentiation ('step-price' model) in the wholesale prices. For high volume data sessions, wholesale rates substantially below € 1,00 per MB must be negotiated. Retail data charges for high volume usage being a couple of Eurocents, a wholesale roaming rate (for high volume sessions) below € 0,10 per MB might – from a retail pricing perspective - be the target for wholesale roaming teams. In addition to this retail perspective, mobile operators need to relate these ambitions on wholesale charges to the future cost levels for a data MB and a data roaming MB. Wholesale rates at levels below cost might cause huge financial risks for operators. This can be especially challenging for smaller operators that have low numbers of data customers.

- Introduction of new and improved retail offers. Knowing that current data roaming volumes are low, it is likely that operators will improve the retail offers in order to generate more revenues. This will be most likely for the data roaming sessions generating large volumes. The 'business case' for such an approach can be very positive to an operator. The situation for data roaming might in this respect be different from that for voice roaming, since a more substantial elasticity can be expected for services like laptop usage abroad.

In addition to this, it is necessary that customers are actively informed on their retail price plans for data roaming and on the data volumes consumed (preferably on a near real time basis) when abroad.

Regulatory challenges

When considering data roaming regulation it is important to keep the following in mind:

1. There is no single price per MB. Prices differ per service being offered. This means: regulation at a price per MB can have an impact on the business model that operators use. This is not only the case for roaming data services but also for national data services. Regulating data roaming can have an impact on the voice roaming regulation. The regulated voice wholesale rate of € 0,30 is equivalent to € 0, 60 per MB rate in case of a VoIP service.

2. The market issues on data roaming are:

- Extremely high bills while roaming

- Limited usage of the service because of high rates compared to national data usage

3. The main issue relates to services generating high volumes in a limited time period. For services like for instance Blackberry this does not seem to be the case

4. Price regulation may not deal with all market issues in a situation when customers are not aware of data volumes consumed while roaming and are not aware of the price plan they are in (including the billing increments used and the number of data sessions the service generates)

5. Current retail data prices at the domestic level might not necessarily reflect future cost levels. This means that current retail domestic data rates might not be the right benchmark when considering regulation of data roaming rates

6. Some operators might be in a different position (from a cost perspective) because of the underlying technology being used, because of the level of utilization of the network and because of the data roaming volumes.

7. Small operators and groups might be in a different position than large operators and groups when negotiating wholesale rates with preferred and non-preferred partners and in translating these into an attractive retail data roaming offer

8. Currently the underlying data roaming wholesale rates limit some operators in bringing attractive offers to the market for services generating high volumes. When improved wholesale rates are negotiated, it can be expected that some operators will improve their retail data roaming rates for high volume sessions, making sure that they generate more volumes and/ or revenues and that the service is competitive with Wi-Fi services offered when abroad.

9. Customers have more alternatives available such as Wi-Fi or a second mobile provider for data services that is different from their provider for voice services.

10. Defining a price level for regulation will be difficult when looked upon from a cost perspective. First because there is little experience with data cost calculations and secondly because of the relatively small current volumes and of the potential cost differences between different operators.

Contents

1 Introduction

1.1 Preface

In the summer of 2007 the wholesale and retail rates for mobile voice roaming became subject to EU regulation. This was decided after the national regulatory authorities had concluded that the analysis made under the then current regulatory framework could not provide any proof of dominance on the market of wholesale roaming services. This kept the National Regulator Authorities (NRA) from setting ex ante obligations for the wholesale roaming rates. However, the NRA's analysis in some cases indicated that the markets for both retail and wholesale roaming showed signs of limited competition and was characterised by a high level of prices.

Currently, mobile roaming data rates are not subject to EU regulation. The Roaming Regulation however stipulates that the European Commission should review the functioning of the Regulation and report to the European Parliament and the Council no later than 30 December 2008. The Commission must review the developments in wholesale and retail charges for the provisioning to roaming customers of voice and data communication services, including SMS and MMS, and shall, if appropriate, give recommendations regarding the need to regulate these services.

In the EU, the rates for data roaming services are perceived to be high. This is the case in particular for users with laptop computers, which will transmit high volumes of data traffic. The unpredictable nature of the volume of data used, in combination with a price plan on a fee per MB basis, is causing 'bill-shocks' to some customers returning from a holiday or business trip. On the other hand, for Blackberry usage this complaint is not often voiced because the international volume is sometimes included in the monthly rate and/or the volume used is limited.

The situation described above causes reluctance among customers to use data services when abroad. Also companies have in some cases blocked their employees from using data services when abroad. This leads to a situation in which the take-up of data usage abroad is slow compared to national data usage.

Coupled with regulatory pressure and shock bills, mobile operators in general recognised that the data rates for roaming were at a level that may prevent customers from using their laptops or smart phones when abroad. In the past year there have been an increasing number of initiatives from operators to lower the wholesale rates and retail rates for data roaming. Examples of initiatives regarding retail data roaming rates are:

- In the summer of 2007 Vodafone launched a price plan in which customers pay € 12,00 (excl. VAT) per day for 50 MB of data roaming services on Vodafone networks

- The H3G Group launched the 'roam like home' offer in which customers can make use of the H3G networks abroad for exactly the same rates and on the same conditions as in national usage

- In January 2008 Vodafone Netherlands launched multiple offers for customers who have a high volume of data usage abroad. These offers concentrated on bundles with data volumes included. O2/Telefonica, Mobilkom and some other operators have launched similar offers recently

- The Bridge Alliance of mobile operators in the Asia-Pacific region launched a data roaming offer with a monthly flat fee (with a cap on data volume) for customers to roam on the alliance members

- T-Mobile announced a decrease of the roaming data rates in February 2008

- Orange announced on the 21st of May 2008 the introduction of a Travel Data Daily in which customers can use up to 50 MB of data abroad for € 12,00 to € 15,00 per day. In addition it was announced that Orange laptop customers will be informed on their data usage on a near real-time basis.

Examples of initiatives on wholesale data roaming rates between mobile operators are:

- In the summer of 2007 Vodafone announced that the data wholesale roaming rates would decrease to € 0,50 per MB for all data sessions above 200 KB, providing operators agree to this on a bilateral basis

- KPN, H3G and Play announced that they have agreed on a wholesale rate of € 0,25 per MB of data downloaded which is applicable from the 1st of March 2008.

1.2 EU request, study objectives and scope

The European Commission requested a study containing a factual description of the market for both wholesale and retail data roaming as an input to its review of the functioning of the Roaming Regulation.

All views expressed in the report are purely the authors and do not necessarily reflect the views of the EC. The EC does not take any responsibility for the information contained in the report.

This study will serve as input for the European Commission in reaching a decision concerning the need for regulation of data roaming services.

This study focuses on:

- Technical infrastructure needed to offer data services and data roaming services

- Analysis of principal characteristics of mobile data roaming services

- Commercial and economic features for the wholesale and retail markets of data roaming services in the EU

- Analysis of the additional cost for data roaming services compared to national data services.

- Price levels for data services; both national and roaming

This study will not provide recommendations concerning the necessity of regulation, but will provide input for the European Commission to make a decision

The scope of this study is on data services offered via the 'packet switched network'. SMS, MMS and video telephony will be out of scope of this study.

2 Methodology

2.1 General

The general methodology used for this study is:

- Definition and description of the wholesale and retail market for data roaming services. This will include a description of the differences in market characteristics between voice roaming and data roaming.

- Facts and figures. In this study information will be gathered and presented on data services, pricing for mobile data and mobile data roaming, and elements and cost involved in providing mobile data roaming.

- Analysis. Comparison of retail prices for national data usage with retail prices for roaming data usage and incremental cost components required for roaming data services compared to national data services.

- Conclusions and reporting

2.2 Gathering price information

The methodology used for gathering price information on national data services and roaming data services will cover the retail price information and the wholesale price information.

2.2.1 National data usage and roaming data usage

- Select 5 countries within the EU. Criteria for the selection of countries:
  - Penetration use of data services
  - Level of competition in the mobile market
  - Level of retail data roaming rates
  - At least 1 country with the presence of a UMTS/HSPA only network

- Determine data rates (structure, level and conditions (speed, data volume) for both mass and business segment) for all mobile operators

- Based on publicly available sources

2.2.2 Wholesale data services

Rates offered for roaming data usage by mobile operators to foreign operators:

- Distinguish between negotiated and non-negotiated rates
- Since rates are confidential, no exact tariff information can be provided but an indication of those rates (structure, level and conditions) will be given based on market knowledge

2.3   Cost Analysis

A detailed cost analysis for mobile data services is not in the scope of this study. Conducting such a detailed analysis would be complicated. The main reasons for this are:

- For data services there is no benchmark available (as a result of regulation) as is the case for voice rates
- Cost analysis for data networks may not be realistic because several mobile data networks currently are under-utilised
- Cost of UMTS licenses would have to be assigned

Instead of a detailed cost analysis for data services, cost analysis will be executed on an incremental cost basis as follows:

- Cost components for data roaming services will be determined
- An evaluation will be executed to analyze if these components lead to incremental cost for roaming data compared to national data
- Analysis of scenarios for incremental cost for roaming data services

3 Regulatory framework

3.1 Relevant regulatory framework

3.1.1 General

Under the 2002 Regulatory framework roaming services were potentially subject to regulation. In this framework, market 17 was identified as the wholesale market for international roaming services. In the Commission's revised Recommendation on relevant markets adopted on 17 December 2007[1], market 17 is no longer identified as a relevant market susceptible to ex ante regulation.

In the period preceding the adoption of the Roaming Regulation, it was concluded that the 2002 framework had not provided the regulatory authorities with sufficient tools to take effective and decisive action with regard to the pricing of roaming services within the Community. This led the European Parliament and Council to adopt a Regulation specific for roaming. In adopting the Regulation, European Parliament and Council was of the opinion that retail and wholesale roaming markets exhibit unique characteristics which justify exceptional measures which go beyond the mechanisms otherwise available under the 2002 regulatory framework.

3.1.2 2002 Regulatory framework

The 2002 regulatory framework creates the possibility for National Regulatory Authorities (NRAs) to impose ex ante obligations on operators designated as having significant market power in markets in which there is no effective competition. Of course, in addition to this, the competition authorities have the possibility to address the competitive failures within certain markets on an ex post basis.

Market 17 concerned the market for wholesale international roaming services. No retail market for international roaming services has been defined as a relevant market. This is due to the fact that roaming services at retail level are not purchased independently but constitute only one element of a broader retail package purchased by customers from their home provider.

3.1.3 The roaming regulation

The Regulation imposes obligations for voice roaming tariffs at both the retail and wholesale level to protect the interests of roaming customers. The main reason for imposing retail obligations was that the decision makers were of the opinion that the reduction in wholesale prices due to negotiations had not been sufficiently reflected in lower retail prices and was thus not being passed on to the consumers. Although the primary objective was to lower charges at retail level, it was concluded that addressing the level of the wholesale charges was also necessary to prevent the disruption of the orderly functioning of the Community wide roaming market.

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[1]   Commission Recommendation of 17 December 2007 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services 2007/879/EC (OJ L 344, 28.12.2007, p. 65).

The Eurotariff was set at a level to guarantee a sufficient margin and encourage competitive roaming offerings at lower rates. The regulatory approach was intended to ensure that retail charges for roaming provide a more reasonable reflection of the underlying cost involved in the provisioning of the service. For the wholesale rates the mobile termination rates were used as a benchmark. For the retail margin, which operators can charge on top of the wholesale rates, operators should be able to cover all specific roaming costs at retail level, including appropriate shares of marketing costs and handset subsidies and be left with an adequate residual to yield a reasonable return.

The regulation applies to post paid and prepaid for all mobile operators, service providers and Mobile Virtual Network Operators (MVNO).

The regulation also introduced obligations concerning the transparency of rates to the end customer. Often, customers were not aware of the tariffs charged to them when roaming abroad. The regulation now obliges operators to send an SMS when the customer arrives in a country, explicitly informing the customers on the price per minute. Moreover, the customer must have the possibility to receive additional tariff information free of charge.

3.2   Framework items relevant for this data roaming study

Taking into account the considerations in the regulatory framework and the regulation adopted for voice roaming services, the following elements are identified as relevant when studying the market of data roaming services:

- Services offered versus bearer technology used. This is explained in chapter 4 on Technology and chapter 6 on Services

- Cost elements involved in roaming data services are identified in chapter 13

- Traffic steering, Groups and alliances and IOT negotiations will be explained in detail in chapter 8 on the wholesale market

- Substitution of services is part of chapter 9

As well as a general description of the retail and wholesale market, there will be an exploration of these elements in more detail in this study.
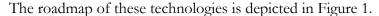
4 Technology

4.1 Introduction

In Europe, the major developments and implementations of mobile communication relate back to the launch of the Global System for Mobile Communication (GSM) in 1992. The initiative for this development had been taken by the members of the European Union. GSM became extremely successful and has evolved into an ad-hoc world standard for mobile communication. GSM was developed primarily to support voice services although, at an early stage, messaging (SMS) and circuit-switched data services were available.

After the standardization for GSM had been completed, new technologies were standardised such as General Packet Radio Service (GPRS), Enhanced Data rates for Global Evolution (EDGE) the Universal Mobile Telecommunication system (UMTS) and High Speed Data Access (HSPA)

The roadmap of these technologies is depicted in Figure 1.
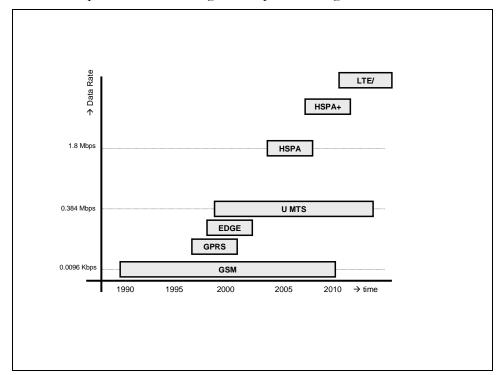
Figure 1 Roadmap Mobile Communication

The latest step in implementation for mobile operators has been HSPA. Future steps will be HSPA+ (evolved HSPA) and Long Term Evolution (LTE).

Global System for Mobile Communication (GSM) was designed primarily for voice services. In the GSM standardization a data service was called 'GSM Data'. This data service was a low speed service (maximum data rate 9.6 Kbps). The service also supported international roaming. It did not attract many subscribers and was not often used. The service allowed for low speed web browsing, email text service etc. As part of the GSM system an update of this data service was standardised: High Speed Circuit Switched Data (HSCSD) that enabled higher data speeds.

HSCSD was very inefficient and required large capacity extensions in the radio network to actually provide higher data rates. Many European mobile operators did not implement this technology. GSM is generally referred to as 'Second generation' Mobile Communication or 2G.

General Packet Radio Service (GPRS) GPRS enabled the use of packet data services, as an overlay network on top of the core network architecture for GSM. The radio network of GSM could be re-used applying the same spectrum and a new packet core network was required to deliver data services using the internet (IP) protocol. GPRS, as the stepping stone between GSM (2G) and UMTS (3G), is generally referred to as 2.5G.

Enhanced Data rates for Global Evolution (EDGE) In Europe, many mobile operators as of 2000 jumped to UMTS and did not introduce EDGE. EDGE is an acceleration of GPRS using the GSM radio network and the GSM spectrum. The improvement of data speed compared to GSM and GPRS is due to more efficient modulation techniques leading to higher throughput of data. Outside of Europe, but a later stage also within Europe, EDGE became a cost-effective alternative for UMTS for many operators, in view of the fact that EDGE does not require a new license for spectrum as was necessary for UMTS.

Universal Mobile Telecommunication system (UMTS) The radio access method WCDMA is applied in the UMTS standardization. WCDMA is one of the radio access methods that were standardised by the International Telecommunication Union (ITU) IMT-2000 program. WCDMA is a part of UMTS that has a broader scope by standardizing both radio network and core network capabilities. UMTS and WCDMA are generally referred to as 'Third generation' Mobile Communication or 3G. The radio network principles as well as the radio spectrum in WCDMA completely changed compared to GSM, meaning that UMTS was a major investment for mobile operators since the GSM radio networks could not be re-used. Although leading to major improvements in data service capabilities, such as data rates (downlink) of up to 384 Kbps, the breakthrough of 'mobile internet' or 'mobile data' still was a troublesome path in the telecommunications industry.

High Speed Data Access (HSPA) HSPA clearly makes the difference for the telecommunications industry in launching mobile data and meeting its business targets. HSPA consists of an improvement of data rates for both the downlink (High Speed Downlink Packet Access, HSDPA) and the uplink (High Speed Uplink Packet Access, HSUPA). Additional improvements of HSPA are the increase of network capacity and shorter delay time (latency) for data transfer. HSPA re-uses the WDCMA access methods in the radio network in the same spectrum as UMTS and therefore requires minimal change to the existing UMTS network. The improvement in HSPA compared to UMTS is due to more efficient modulation techniques, to the realisation of shared HSPA data traffic channels, and faster processing of data packets. Typical (peak) data rates for HSDPA are 1,8 up to 3,6 Mbps.

The next step in the evolution builds on top of HSPA and is referred to as 'Evolved HSPA' or HSPA+. This enables peak data rates of up to 42 Mbps on the downlink and 11 Mbps on the uplink, using WCDMA networks and the frequency spectrum.

Long Term Evolution (LTE) There is a continuous evolution from HSPA and HSPA+ to HSOPA that is part of the 'Long term Evolution (LTE)'. High Speed OFDM Packet Access (HSOPA) is a proposed part of 3GPP's Long Term Evolution (LTE) upgrade for 3G/UMTS systems. HSOPA networks require a new radio air interface because this technology is not compatible with WCMDA.

LTE will introduce new data services and a new radio interface to the mobile communication networks using a new access method Orthogonal Frequency Division Multiplexing Access

(OFDMA) in the downlink. This is the same method as is applied in WiMAX. The technology is still in the development phase, and promises a performance of 100 Mbps peak rates in the downlink and 40 Mbps peak rate in the uplink.

A key objective of LTE is the implementation of an 'All-IP network'. This means that all services will be based on IP protocols and that all services will use a packet-switched data bearer service. Circuit-switched service ('plain old voice') will no longer exist in such a technological environment although there will be backward compatibility for GSM/GPRS and UMTS/HSPA. One of key issues for the All-IP network environment is assessing the role of the current interconnection between networks for voice services.

Standardization issues concerning mobile communication will be further explored in Appendix I.

4.2 Circuit switching and Packet Switching

Packet switching is a communications concept in which data packets (blocks of data) are routed between network nodes over data links that are shared with other traffic. In each of the network nodes the data packets may be put in a queue or a buffer, resulting in a delay. By contrast, circuit switching allows a limited number of connections between network nodes resulting in constant bit rates and constant delay. A connection is exclusively available for the duration of the communication.

Regular telephony – Public Switched Telephony Networks (PSTN) – and also GSM makes use of circuit switching to provide conversational services such as voice. In these networks first a connection between calling party and called party is established before communication starts to take place. The advantage of circuit switching is that the quality of the communication can be guaranteed because a dedicated channel is assigned for the communication. In Packet switched networks it is more complicated to guarantee the quality of communication. On the other hand, in packet switched networks the network capacity can be used far more efficiently.

The most well-known use of packet switching is the Internet and Local Area Networks (LAN). The Internet uses the Internet protocol (IP) suite over a variety of data link layer protocols such as Ethernet, Frame relay, ATM, Wi-Fi etc.

4.3 Overview of technologies (data rates)

Data Speed is one the key drivers, and an important differentiator for the evolution and development of mobile communication. The (practical) peak data rates for the mobile communication technologies are summarised as follows:

	(practical) peak data rate		Access technology	Remarks
	DOWNLINK	UPLINK		The peak rate
GPRS	56 Kbps	56 Kbps	TDMA/FDMA (GSM)	The peak rate for GPRS is a theoretical value of 171.2 Kbps that has no practical meaning.
EDGE	180 Kbps	180 Kbps	TDMA/FDMA (GSM)	The peak rate for EDGE is a theoretical value of 473.6 Kbps that has no

				practical meaning.
UMTS	384 Kbps	64-128 Kbps	WCDMA	
HSPA	1.8-3.6 Mbps	2.1 Mbps	WCDMA	Peak rate for downlink is 14.4 Mbps, but this is currently not available.
LTE	100 Mbps	40 Mbps	OFDMA, SC-FDMA	
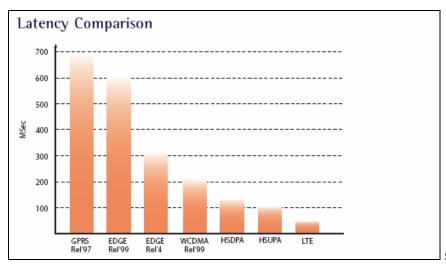
The (practical) peak data rate for WCDMA is 384 Kbps. HSPA is able to push data rates up to 14,4 Mbps in the downlink (from the network to the terminal) and 5.76 Mbps in the uplink (from the terminal to the network). The practical peak rates for HSPA, in the downlink, are 1,8 to 3,6 Mbps.

4.4   Overview of technologies (Latency)

'Latency' in telecommunications can be defined as the round trip (delay) time that is the elapsed time for the transfer of a signal over a closed circuit, or time elapsed for a message to a remote place and back again. It defines the time that a digital 'bit' requires to travel through a system.

Improving the latency is a key driver in the development of mobile communication. In particular for HSPA technology the latency has improved to such levels that the application of real-time interaction applications such as voice, video communication and gaming applications becomes feasible.

In GPRS and in UMTS, services like VoIP are not feasible due to the delay that these systems cause. A latency comparison is depicted in Figure 2.

Source Rysavy Research/3G Americas

Figure 2 Latency comparison

4.5   Overview of technologies (Spectrum, modulation)

	Spectrum		Modulation	Remarks
	UPLINK	DOWNLINK		
GSM900	880-915 MHz	925-960 MHz	GMSK	
GSM1800	1710-1785 MHz	1805-1880 MHz		
GPRS	same as GSM	same as GSM	GMSK	
EDGE	same as GSM	same as GSM	8PSK	
UMTS	1920-1980 MHz	2110–2170 MHz	QPSK	This is the UMTS FDD mode spectrum consisting of 12 carriers of 5Mhz
HSPA	same as UMTS	same as UMTS	16QAM, QPSK	
LTE/HSOPA			64QAM, 16QAM, QPSK	LTE may be launched on a number of frequency bands – on 2.6GHz and on existing 3G spectrum etc.

The common GSM bands in Europe are in 900MHz (GSM900) and 1800 MHz ranges (GSM1800). Globally there are other spectrum bands applied for GSM:

▪ GSM450 in the 450.4-457.6 MHz (uplink) paired with 460.4-467.6 MHz (downlink) or 478.8-486 MHz (uplink) paired with 488.8-496 MHz (downlink)

▪ GSM850 in the 824 - 849 MHz (uplink) paired with 869-894 MHz (downlink)

▪ GSM1900 in the 1850-1910 MHz (uplink) paired with 1930-1990 MHz (downlink). GSM1900 is the spectrum that is applied in the United States

For UMTS an extension band in the range of 2500-2690 MHz is available for application (status in Europe).

It should be noted that HSPA, but also LTE, apply 'adaptive modulation' meaning that depending on the radio link properties a best fit (optimal) modulation will be explored. For instance for HSDPA adaptive switching between 16QAM and QPSK takes place if the radio link properties deteriorate.

4.6   Overview of technologies (Spectral efficiency)

Spectral efficiency for radio systems can be expressed in the number of bits per second that can be conveyed per unit of Frequency. The spectral efficiency is expressed in bit/s/Hz. For example, if a system transmits data at a speed of 50 Kbps in a spectrum with a bandwidth of 200 KHz the spectral efficiency is 0,25 bit/s/Hz. It defines the efficiency for the frequency spectrum to be used for data communication. In the evolution of mobile communication the spectrum efficiency is developing as illustrated in the following table:

System	Spectral efficiency (bit/s/Hz)
GSM	0,52
EDGE	Typical = 1,00, max = 1,92
WCDMA (UMTS)	max 0,077 (per mobile)
HSDPA	max = 2,88 (per mobile)
LTE	max = 16.32 (per mobile)
Wi-Fi (802.11 a/g)	2,7
WiMAX	4,8

It should be noted that the spectrum efficiency is a value that is derived from the radio interface and systems characteristics. It does not take into account how a mobile operator has designed and rolled out radio coverage.

The improvement in spectral efficiency is enabling a significant decrease in the cost per bit transmitted and could improve the cost structure for offering data services. This improvement is valid both for national data as well as for roaming data. This improvement is applicable under the assumptions that:

- Cost of spectrum use should be of the same value. A higher cost of spectrum use would have the opposite effect and have an increasing effect on the cost per bit

- Cost of the radio system should be of the same value. A higher cost of radio system would have the opposite effect and have an increasing effect on the cost per bit

- The spectral capabilities in the system should be optimally used in order for them to pay off for the capacity installed

The improvement of spectrum efficiency as a result of the evolution of mobile communication is enabling lower data conveyance cost in the radio networks, because more data can be sent in the same amount of frequency bandwidth.

4.7   Overview of technologies (Cost effects)

It should be noted that the radio propagation characteristics of the spectrum that is used are important for the cost structure of the mobile communication network. As described in section 4.5, in Europe the UMTS networks explore 1920-1980 MHz (uplink) and 2110-2170 MHz (downlink). Recently regulatory actions have been taken or are underway in Europe but also in the Asia Pacific region to deploy WCDMA (and HSPA) in the 900 MHz spectrum, which is currently exclusively used for GSM. This application is called UMTS900. Due to the lower frequencies in the 900 MHz spectrum, UMTS 900 delivers improved wide area coverage and improved indoor coverage and is an important consideration for cost efficiency for many operators.

According to data in the GSM suppliers association fact sheets (www.gsacom.com), very substantial cost savings can be achieved of up to 60% in rural areas. In this way, the cost price for data services highly depends on the spectrum available to the mobile operator.

Not only the spectrum is a key differentiator for cost price but also the technology applied whether GPRS, UMTS, or HSPA has a different effect on the cost price. The variation in cost price due to differences in technology and spectrum are complicating factors in defining the cost price for data services.

Customers in many cases are not restricted to just one technology because there are multi-mode and multi-band terminals, and handover support between the various network technologies, and technology independent rate plans.

4.8   Other Technologies

4.8.1 Wi-Fi (IEEE802.11)

Mobile access services such as Wi-Fi (or WLAN) have become widespread for stationary and indoor wireless mobile data applications. This enables (fast) access to internet service providers allowing basic services such as email, web-browsing etc. Wi-Fi is standardised in the IEEE802.11 specifications that have various versions allowing for increasing bandwidth. IEEE802.11a allowed for peak rates of 11 Mbps, and IEEE802.11g allows for peak rates of 54 Mbps. Capabilities for roaming between networks and handovers between sites have been minimal compared to the capabilities that GSM networks have developed.

Some mobile operators have explored Wi-Fi services as part of their portfolios as additional services to UMTS and HSPA for mobile data. Business revenues have been limited compared to cellular applications. Wi-Fi has primarily become successful for private and stand-alone applications, as well as for semi-public applications in Hotel, Business Centres, Airports etc. Wi-Fi is also named 'WLAN'

4.8.2 WiMAX (IEEE802.16)
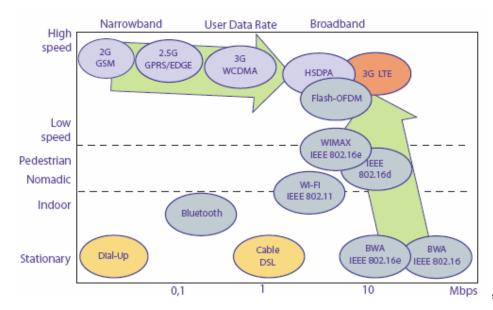
WiMAX deployment and usage is growing. The latest version (IEEE802.16e) is a mobile version of the point-to-point mobile applications that have been dominant for WiMAX.

WiMAX caters for data rates in the region of 70 Mbps (peak theoretical rates). For the mobile WiMAX systems (IEEE802.16e) the theoretical data throughput is 20 Mbps. Typically the data rate could be in the area of 10 Mbps (close to the base station). The data rate should be shared by several users and shared for both directions.

Wireless technologies, initially just allowing for high data throughput, are evolving into mobility support technologies. Cellular networks such as GSM and UMTS, which initially only supported full roaming and handovers are evolving into systems providing bandwidth availability to end users. As a result of the technological developments and the specification of similar access methods (OFDMA, Orthogonal Frequency Division Multiple Access) the gap between wireless technology and cellular technology is closing and WiMAX and HSOPA/LTE will become matching technologies.

Figure 3 depicts the evolution of Wi-Fi and WiMAX versus GSM, UMTS and HSPA.

source: Siemens, UMTS forum

Figure 3 Evolution of Broadband Mobile data

In addition, in October 2007 the International Telecommunication Union (ITU) decided to include WiMAX technology in the framework of the 3G set of standards (IMT-2000). This will encourage the dual application of these technologies and opens the door to the development of mobile devices and infrastructure equipment for a range of services.

Currently, mobile operators in Europe commonly apply GPRS, EDGE, UMTS and HSPA technologies to offer packet data services. These technologies build a more or less seamless data transfer service to the users since it is possible to actively and automatically switch between these technologies. Switching between these technologies obviously results in a change of performance in terms of data rate, latency and capacity. The data services based on these technologies are also generally available during roaming in other networks than the home network. Although some of the operators apply Wi-Fi based services and even WiMAX services, these currently show limited capabilities for roaming, as well as limited coverage. In this study for data roaming in Europe the focus therefore is on GPRS, EDGE, UMTS and HSPA.

4.9 Status of Mobile Data in Europe

The roll-out of 3G networks in Europe, after the licensing of the UMTS spectrum early this century, initially could not meet the high expectations in the market. It took until 2004 before 3G networks became widely available.

Looking back, it can be concluded that HSPA technology was required to make the 'mobile broadband' that UMTS promised come true.

Currently in all European member states, one or more 3G networks are operational. Globally, there are around 207 million W-CDMA subscribers including 25 million HSPA users. Approximately 50% percent of the total W-CDMA subscribers are in Europe (and 45% are in Asia). Approximately 14% of the HSPA subscribers are in Europe (40% is in Asia and 40% is in the United States). Globally there are 182 W-CDMA networks and 116 networks that support HSPA.

The countries in Europe that have the highest penetration of W-CDMA are Luxemburg (34%), Ireland (30%), Portugal (28%) and Italy (26%).[2]

The drive of the GSM industry to make 3G technology, UMTS and HSPA in particular, a success has been tremendously strong in order to compete with emerging technologies such as Wi-Fi and WiMAX and with CDMA2000 and EV-DO. The outlook for HSPA is positive. Forecasts show a growth to 1 billion users in the year 2012, as is depicted in Figure 4.
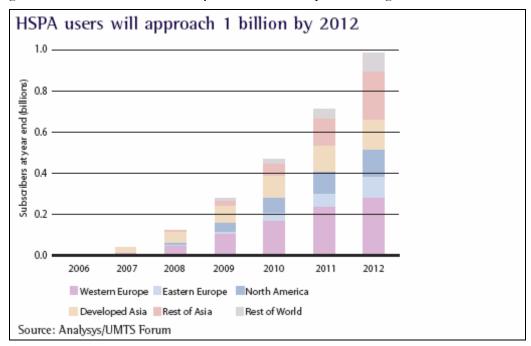

Figure 4 HSPA growth forecast

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5 Network architecture and components

This chapter describes the network architecture for the data packet services. Although there are differences between the various technologies the common concepts are:
- Radio network
- Core network

5.1   Radio network

The radio network in GSM consists of base stations (BTS) that each serves a certain geographical area, with a diameter of several 100 meters to several kilometres. These base stations in WCDMA are referred to as 'node-B'. Mobile terminals make connections via the antennas of these base stations to the network. The base stations are connected to a controller system (in the case of UMTS this is the Radio Network Controller, RNC. In the case of GSM this is the Base Station controller, BSC). The radio network will consist of several of these controller systems, depending on the size of the network and the required capacity.

In the case of a national data service the radio network in the home country (network) is used. In the case of a roaming data service the radio network in the visited country is used. The network controllers in the radio network connect to the core network elements. The radio network is depicted in Figure 5.

5.1.1 Handover

The radio networks in GSM and UMTS are separate networks, although some of the hardware could be shared such as a site, a tower, power equipment or transmission equipment. In the networks there are capabilities to support handovers between technologies. This means that for a moving subscriber a data session could start in a UMTS network using HSPA, is handed over to UMTS (and thus a reduction in maximum speed), and onwards to GPRS. These handovers take place in a seamless way, although there will be a different quality of the service as a result of the handovers. Whether these so-called 'inter-technology handovers' take place depends on the radio network coverage for the various technologies, the capacity that is available as well as on networks and terminals preferences and configurations.

It should be noted that handovers are a basic capability within mobile networks in order to support the mobility of subscribers while making calls or having data sessions.

5.1.2 Network selection

A mobile terminal has settings that define the preferred network technology. For example 'GSM only' or '3G preferred'. These settings depend on the type of mobile terminal.

Also the network could have a preference to push subscribers to a preferred network technology e.g. to the fastest radio network, or to the network best suited for voice. Mobile operators could also have a policy to e.g. execute voice services on the GSM network, and data services on the UMTS or HSDPA network. There may be cost considerations as well as quality of service considerations behind these policies.

The Universal Integrated Circuit Card (smart card) for the mobile could carry a SIM application or a USIM application. USIM is the 3G version of the SIM card.

Mobile operators may have different policies for applying these smart cards. Some operators provide USIM cards to the UMTS and HSDPA subscribers and do not allow SIM cards to access UMTS and HSDPA, while other mobile operators have a transparent approach and allow both SIM and USIM to access UMTS and HSPA.

Mobile operators may have different commercial approaches for access to data networks.

Operators could have different rate plans for different technologies (QoS based approach) having a price per MB that depends on the maximum data speed. In contrast mobile operators could have a general price plan that does not differentiate for QoS.

As a conclusion; the network that will be used by the subscriber depends on coverage, handover settings and capabilities, terminal settings, network preferences, SIM/USIM and price plan options.

5.2 Core network

The core network consists of components for packet switching and components for circuit switching. The components for circuit switching will not be described as part of this study.
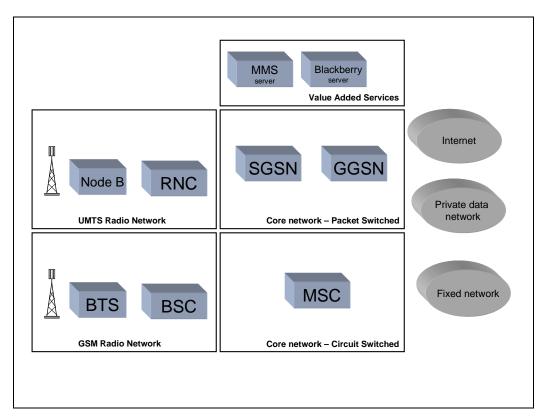

Figure 5 Overview mobile communication network

The core network consists of several components to set up data sessions. The main components are the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN). SGSN and GGSN are applied for GPRS as well as for EDGE, UMTS and HSPA packet data service.

The SGSN manages the mobility of the mobile terminal, meaning that it keeps track of its location and manages the data connection towards the radio network.

The GGSN manages the connectivity to the destination for the data session. This could be the internet, a corporate network or a private data network, MMS-server, Blackberry server etc. In the case of a national data service both SGSN and GGSN are applied in the home network.

5.3   Data roaming components

In the case of a roaming data service there are two possibilities:

- Both the SGSN and the GGSN in the visited network are used
- The SGSN in the visited network and GGSN in the home network are applied

The first possibility is called 'local roaming' or 'ISP roaming', while the second possibility is called 'home roaming'. In the model of local roaming, the visited operator network directly brings the data traffic to the 'final destination'. However, this model is implemented almost nowhere. Most operators, if not all, have decided for a home roaming implementation. It should be noted that the home operators in the client profiles decide on the type of roaming to be applied. The home roaming implementation has several advantages:

- Service platforms (e.g. the MMS server) and content servers for value added services are connected to the GGSN in the home network. Using home roaming the value added services can be used while roaming. In case of local roaming the connectivity from each of the roaming partner networks to these (home) platforms would be complicated. The home roaming implementation enables users to utilize the same services as if in the home network. The same applies to corporate networks that have dedicated connectivity to the mobile operator data networks (VPN, leased lines etc.). This dedicated connectivity is not sufficient in the case of a local roaming implementation.
- As the data sessions are routed through the home network there are better means for charging the services independent of the roaming partner network usage data (TAP usage data). The concept of home routing creates the possibility for the home operator to generate its own Call Detail records (CDR) in the home GGSN and to use these for retail billing purposes instead of using the CDR received from the visited operator.
- As the data sessions are routed through the home network there are efficient means for offering data roaming services to prepaid customers and enabling real time charging. This could be implemented independent of the roaming partner networks. This is different from voice prepaid services that highly depend on the roaming partner network support.
- As the data sessions are routed through the home network there are efficient means for monitoring usage, prevention of fraud and misuse. This is different from voice services that highly depend on the roaming partner network support to provide e.g. High Usage Reports or near real time usage data.
- Using the local roaming option may require the roaming customer to change settings in the mobile handset (such as the APN). These settings may differ per roaming network.

In case of home roaming, the SGSN in the visited network and the GGSN in the home network need to be interconnected. Although there are various technical options, the most common solution for this interconnection is the use of a GPRS Roaming Exchange (GRX).
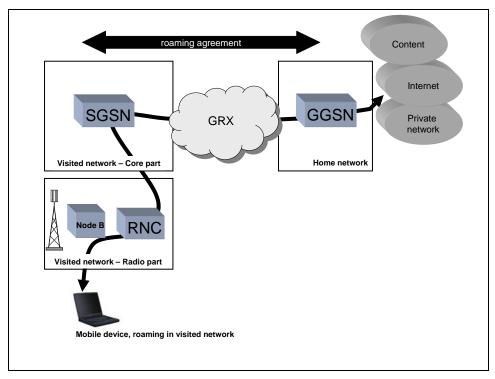
Figure 6 Home Roaming scenario using GRX

A GRX is a peering exchange between different mobile networks. It provides a secure and private exchange between a home network and roaming networks that are connected to several GRXs. There are several of these GRX implementations worldwide that are interconnected, and are commercially available to the mobile operators.

Figure 6 depicts the home roaming scenario using GRX to connect the network components in the visited network to the components in the home network. In the home roaming scenario data packets will be exchanged between the mobile device and the destination (e.g. internet) via the radio network of the visited (roaming) network, the SGSN in the visited network and the GGSN in the home network. This means that all data are routed via the home network.

It should be noted that the mobile industry is currently considering replacing GRX solutions by IPX solutions (IPX, Internetwork Packet Exchange) to support VoIP service as well as IMS network infrastructures.

5.4   Data session principals

In packet data networks such as GPRS, UMTS and HSPA there is the concept of a 'data session'. In the standards for these networks this is referred to as 'PDP context'. PDP stands for Packet Data Protocol. During a PDP context the user is connected to the APN (Access Point Name). As soon as a Mobile Terminal is switched on it will register to the home network (or to the roaming network). In a next step the PDP context activation takes place in which the terminal selects an access point at the GGSN to e.g. internet, a content server, a corporate server etc. It means that the user is able to start sending data. The PDP context activation could be started automatically or manually.

During the PDP context activation, data will be sent and received, but not necessarily in a constant flow. In this way PDP context activations or data sessions could last a long time, and could capture several instances of active data exchange.

For public Wi-Fi services it is very common to charge for the total duration of such sessions by providing a subscription that allows for a certain time of connection, irrespective of the amount of data sent/received. Alternatively, time duration (1 hour, 1 day, 1 week) could be subscribed to, irrespective of the time of connection or the data amounts sent/received.

It should be noted that in both cases a 'fair usage policy' may be applicable, meaning that there are certain restrictions to the maximum data amounts to be sent and received.

In mobile communication networks it is more common to charge for data volumes. For a single PDP context activation, also referred to as 'session', one or several (partial) CDRs could be generated. Operators are faced with the complexity of 'aggregating' these partial CDRs to one session charge before actually rating the session.

The session length may depend on the behaviour of the mobile terminal and/or the mobile network. In addition a data session may be terminated if there has been no active data transfer for a certain period of time.

In practice there will be differences in charging of data services in the following situations:

- several short transfers of data in one session
- several short transfers of data each in a single session

Take for example the following case: a minimum of 10 KB is charged and 10 emails of each 4 KB are transferred. In the first situation a data volume of 40 KB will be charged. In the second situation a data volume of 100KB is charged. In this example, the second situation is obviously more expensive to the subscriber.

Whether single or multiple sessions are executed depends on the terminal and on service settings. As an example: a Blackberry device – as long as it switched on, and is within network reach – will support one session.

The relevance of the session length should be taken into account in evaluating regulatory measures for data services.

If the aggregation of CDRs (per session) is not correctly executed similar situations as described above may exist, leading to higher data rates per MB.

5.5   Steering of Roaming methods

Many mobile network operators have applied methods for steering of roaming. In this way a mobile network operator can force traffic to a particular roaming partner network, or manage the distribution of traffic over several roaming partner networks. There are several methods for this so-called steering of roaming. These methods make use of the following techniques:

- PLMN list: A SIM or USIM card contains a preferred operator list (PLMN list). This list contains the preferred networks for network registration. The SIM card may have a default PLMN list that is loaded onto the card during the production of the SIM card. The user can makes changes to the SIM card through the mobile handset.

- Over The Air (OTA): OTA is a method to add or modify data or applications on the SIM card via the mobile radio path. This can be done by the mobile operator without the user noticing this.

- Location Update: The location update procedure is a signalling procedure between the visited network and the home network to register the subscriber to the Visited Location Register (VLR), duplicate user data to the VLR, and notify the Home location register (HLR) of the actual location of the subscriber. A successful Location Update procedure is a pre-requisite for allowing a subscriber to make use of a roaming network

Some of the possible methods for steering of roaming are:

- Update of the PLMN list on the SIM card via (mass) OTA messages to subscribers

- Update of the PLMN list on the SIM via OTA message (on a per subscriber level) upon first attempt to execute a location update from a roaming network

- Disapprove Location Update requests in the home network until requests come in from the desired network

- A combination of updating of the PLMN list on the SIM via OTA message (on a per subscriber level) and disapproval of Location Update requests until the requests come in from the desired network

It should be noted that steering of roaming may have impact on both the network and user: there may be significantly more signalling messages and network load due to location updates, registration of handsets while roaming may take longer and handsets may not be compatible.

Steering has been implemented by mobile operators primarily from a voice perspective in order to reduce wholesale (roaming) costs, improve margins, or optimize roaming retail rates. For data services some new challenges are apparent for steering of roaming. The preferred network for voice roaming is not necessarily the preferred network for data roaming if this data network has an incompatible technology, does not offer the appropriate Quality of Service (e.g. if UMTS or HSDPA are not available to the roamer), or has unattractive roaming retail rates. As a result, if steering of roaming is voice-driven, a handset (laptop, blackberry, PDA) may be steered to a wrong network.

The steering of roaming mechanism could be complicated or even overruled by handset settings as described in 5.1.2

6 Data Services

6.1 Introduction

In this chapter an overview is given on the history of mobile data services, the different data services, the business models and technological developments.

6.2 History

Data services have been offered since the start of GSM in the early nineties. These services were offered over the circuit switched GSM networks. Because of the limited transmission speeds, the use of data services via circuit switched GSM networks was limited. The real start of data services came when GPRS was introduced in 2001-2003. This technology enabled data services at a higher speed. It also provided for a more efficient use of the network since network resources are only used when data is actually transferred. GPRS improved the performance of existing services but also stimulated the development of new data services. The abovementioned development accelerated with the introduction of UMTS and HSPA technology.

The roaming use of data services is dependent on the availability of GSM roaming and GPRS Roaming. Most operators have rolled out data roaming coinciding with the introduction of the national GPRS services. This meant that a customer making use of a national data service would also have the international roaming service available for the countries where GPRS roaming was implemented.

6.3 Data Services

Different services can be offered on the bearer technology for packet switched networks. This distinguishes data services from voice and SMS in which there is basically 1 service to 1 bearer technology.

The following services can be distinguished (source: GSM World website):

Mobile Internet Access: Customers can use a PDA (personal digital assistant) or laptop computer to access the Internet via the mobile network. This enables the customer to use the internet in a similar way as he is used to when using a fixed ADSL or cable connection. Most Web pages are not well suited to viewing on the small screen of a mobile phone, so mobile operators typically offer access to Internet-style services and sites using a technology called WAP. There are hundreds of thousands of WAP sites containing much of the information and images found on the wider Internet. You need a phone with a WAP browser to access these sites. An increasing number of handsets have relatively large colour screens and full Internet browsers that can call-up standard Web pages. A subsection of the main Internet has been created for access by these mobile phones. The address of Web sites belonging to this subsection will end with the suffix '.mobi', rather than '.com' or '.org', signalling to the user that the site has been designed for viewing on a mobile phone.

Messaging Services: Examples of these services are: SMS, MMS, Instant Messaging and E-mail. E-mail services are an important driver for the success of mobile data usage. There is a strongly

felt need among consumers to be able to access e-mail while on the move. These e-mail services can be accessed via a lap top but also via mobile phones that are enabled with an e-mail client. Blackberry is one of the success stories of mobile data services in which operators and vendors created a service with the right combination of network technology, quality of service, devices and price plans.

Entertainment: This concerns services like TV, music and video downloads and gaming. In some case operators offer these services in a separate 'portal' like Vodafone V-live, T-mobile T-zones, Orange World or I-mode.

M-commerce: Services like banking services, e-ticketing, parking meter payments etc.

Machine-to-machine services: For example: vending machines, gas metre reading, international transport, security services, tracking and tracing, video surveillance etc.

Services supporting a company's business processes: This could be, for instance, support for a mobile workforce. Usually these services are dedicatedly designed for a certain customer segment and combine infrastructure, software and devices.

Voice: Packet switched networks can also carry voice services using, for instance, a voice client like Skype

6.4   The impact of HSPA on data services

The major improvements through HSPA technology are

- Improvement of data rates up to 1,8-3,6 Mbps and beyond

- Improvement of the network latency (round trip delay)

- Improvement of Spectral efficiency

Not only does HSPA technology enable the application of services that require sufficient bandwidth but it also makes feasible many real-time applications such as voice, video communications and gaming applications through a significant improvement in latency.

The emergence of services as a result of HSPA technology has been analysed as follows:

Services that remain unaffected for the user: The improvements of HSPA will have no effect on SMS, on circuit-switched voice, video telephony, and low-bandwidth data service (browsing of simple web pages, basic text messaging such as simple email without attachments, email subject downloads etc.). In particular to Blackberry users HSPA does not give significant benefits.

Services that have improved user experience: The improvements through HSPA – compared to GPRS and even UMTS – have enabled computer (laptop) users to have a similar experience with internet access as they have at home or in the office (using e.g. ADSL). Laptop users have full email, download and internet capabilities. The 'Mobile office' becomes truly effective in HSPA environments.

New Services that are enabled by HSPA: video downloads, music downloads and video/audio streaming (theoretically not impossible in pre-HSPA technology) have become reality. Mobile TV is widely applied. Through secure VPN, home workers can efficiently access corporate networks, use corporate business applications download/upload documents, use synchronised

email etc. Improvement of latency is leading to the update of voice and video calling services using internet.

6.5   Managed versus Unmanaged services

Figure 7 Managed and Unmanaged service concept

In the mobile industry, a distinction is made between the concepts of 'managed' and 'unmanaged service'. These concepts are depicted in Figure 7.

'Unmanaged services' are services that mobile customers can access while using the internet or an intranet. The mobile operator just provides and bills the access to the internet or intranet. The customer can then use all services available on the internet like Skype, MSN etc. Payment for these services is settled between the end-user and the service provider without involvement of the mobile operator. This is a model used in the world of the fixed internet. This model is sometimes also referred to as the 'bit-pipe' model. In the market of fixed broadband the dominant offer is a monthly subscription fee based on the transmission speed offered. This gives the customer access to the internet on which the customer can use all kinds of services. Basically, the fixed broadband provider offers the access for the customer and can be seen as 'bit pipe' over which internet based services are provided by parties like MSN, Google, and Skype etc.

In order to offer data services on mobile devices the mobile industry developed the concept of 'managed services'. 'Managed services' are mobile data services that a mobile operator specifically designs for a certain customer segment in which the operator:

- Builds and maintains dedicated infrastructure

- Develops specific software

- Offers a certain quality of service needed for the application

- Offers devices to support the services

- Creates dedicated price plans. Often the operator charges a combined tariff for the data access and the use of the service. Usually there are no separate charges by third parties. This concept of service based pricing is further specified in chapter 7.3.3.3

Examples of these are: Blackberry service, Messaging Service, MMS, Mobile TV, applications to support a company's business processes etc. For 'managed services' the customer ownership is with the mobile operator and the invoicing for these is also taken care of by the mobile operator.

In general, Mobile operators offer the 'unmanaged' and the 'managed' model in parallel and in competition with each other. In some cases, operators have blocked customers from using, for instance, Skype services when using mobile broadband.

6.6 Devices

For voice, a customer needs a mobile phone in order to use the voice service.

For data services a much wider variety of devices is available and necessary to use the service:

- Laptop computers combined with built-in SIM cards and data modems, or with separate cards or modems. These devices are often dedicated for data usage.

- Smart phones/PDAs. Often these devices combine voice and data services on the same device and SIM-card.

- Devices for push mail like Blackberry. Often these devices combine voice and data services on the same device and SIM-card.

In particular in the early days of data services, the (un)availability of compatible devices was one of the factors limiting the growth of data services. The device used is also important from a roaming traffic steering perspective:

- It is important to understand for what kind of usage the combination of SIM and device is intended. For instance, laptop customers are best sent to networks offering HSPA technology in order to offer the best customer experience.

- If voice and data are combined in the same device/SIM the operator needs to decide to which network the customer will be 'steered'; either the network that offers the best wholesale voice rate or the network offering the best wholesale data rate and/or data transmission speed.

- Devices may have a certain preference concerning the selection of networks. For instance, UMTS enabled devices might have a preference for UMTS enabled networks. In this way the customer will be offered the best service available.

6.7 Delivery of data services by MVNO or SP

Parties such as Mobile Virtual Network Operators (MNVO) or Service Providers (SP) could also deliver data services to their end-users based on a wholesale agreement enabling them to use the mobile network infrastructure, or part of that infrastructure.

The mobile operator allows end users of these third parties to enter the network and use data services. The data services could be equivalent to the mobile operator's own retail services (and resold to the end-user), or they could be data services that are specifically designed and implemented for the MVNO. In these situations there is a different approach for MVNOs that

have (part of) their own packet switched network and an SP that uses the MNO core network. The mobile operator, even in the MVNO scenario, has the ability to be in control of the service delivery:

- Access of subscribers

- Availability of the network technology and services to third parties

- Monitoring and defining the quality of service for the services delivered

- Wholesale Charging of data volumes

It should be noted that for service delivery, third parties such as MVNOs and SPs highly depend on the mobile operator for the configuration of their products to the market. In practice, these third parties have limited control over the service delivery and need to negotiate and agree with operators in order to be able to offer data services. In addition, if value added services such as SMS, MMS, Blackberry, PDA support, content services etc. are required these also need to be negotiated with the mobile operator before they can be implemented and become available to the MVNO or SP.

6.8   Typical usage

For consumers of voice service there is a common understanding that time is the unit for charging of the service. This common understanding has been slightly influenced by start tariffs, and minute-bundles. In general, consumers understand that the duration of a call determines the cost. For data services (data) volume, the common unit for charging of the service is expressed in Kilobytes or Megabytes. It should be noted that for the average, non-technically educated consumer 'data volume' is a concept that is difficult to comprehend. Is the consumer aware that 1 byte is equal to 8 bit? Perhaps it is assumed that 1 Kilobyte equals 1.000 bytes and that 1 Megabyte is 1.000 Kilobytes when in fact 1 Kilobyte = 1.024 byte and 1 Megabyte is 1.024. One Kilobyte is 1.048.576 byte.

6.8.1 Examples

Some examples of typical usage of data services are as follows:

Email: A short email containing just a single sentence of ten short words is approximately 4 KB

Internet page: A very simple web page in html format without images would contain approximately 25-50 KB, although a web site containing some basic imaging could be approximately 150-250 KB or more. It should be noted if internet pages contain animated pictures, banners, and video streaming then the data volume will further increase.

File: A file in MS Word consisting of an A4 page text is approximately 26 KB

Image: A JPEG coded picture (size 10*15 cm) at a 100 pixels/cm is approximately 488 KB (low level of compression, high quality picture)

Audio: An MPEG Audio layer (MP3) coded music song of 3.32 minutes sampled at 320 Kbps will take 8,3 MB

Video: An MPEG coded video (video 608*452) of 2.12 minutes will take approximately 40 MB

These examples are depicted in Figure 8.

If a video (e.g. at Youtube) is watched using a mobile phone at a speed of 80 Kpbs, a video of 1 minute would take 600 KB. Supposing the data roaming rate is € 10,00 per MB, watching this video would cost € 6,00. A 10 minute video (e.g. a news update) would cost € 60,00.

If a movie is watched using a mobile phone at a speed of 384 Kpbs, a movie of 2 hours would require 346 MB. Supposing the data (roaming) rate is € 0,10 per MB, watching this movie would cost € 34,56.
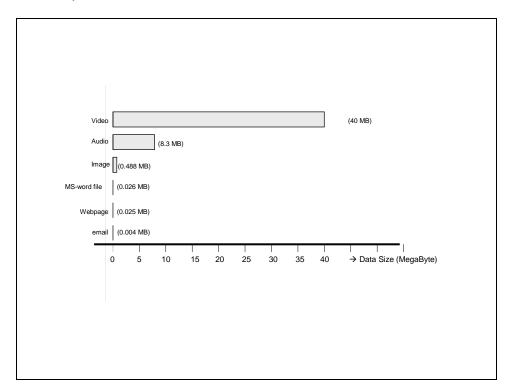
Figure 8 Typical usage and data size

It should be noted that actual data volumes required for sending images, audio, or video will depend on the resolution of the data. The higher the resolution, the better the quality of the reproduction and the better the original can be matched. However, higher resolution leads to larger data volumes (and occasionally more expensive data sessions). The resolution is expressed e.g. in bits/sec in case of audio, or in pixels/cm in case of a picture.

For a consumer to comprehend the amount of data required for a certain data transfer like video, audio etc. the quality of the service is of influence. In terms of the acceptable charge for such a service this is a matter of price-quality evaluation.

As an example; when watching a movie or a TV program using a mobile data bearer service a newsreader, sitting quietly behind a desk, hardly moving would allow a much lower resolution (and thus data volume) than a football game or a tennis match that would need much higher resolution (and higher data volume). For the consumer this would result in different costs for TV programs that have the same time duration.

6.8.2 Measuring the volume of data usage

In charging for data services to subscribers there are a number of issues that could cause lack of transparency about usage:

End user knowledge/awareness:

- A customer may not know what a Megabyte is. A Kilobyte is 1.024 bytes, and a Megabyte is 1.048.576 byte. This will mean that data pricing is difficult to comprehend if it is expressed in € per Megabyte.

- In general, customers who do not have the technical knowledge to understand how much data is being used, will have difficulties understanding how much data is transmitted for a certain service and thus will find it difficult to fully understand the cost for the transmission of the data. In addition, the customer may not be aware of the speed of data transmission.

Expected data volume vs. actual data volume:

- There may be retransmission of data (due to transmission failures) leading to higher data volumes than expected

- E.g. for laptop computer users there may be unexpected and unintended data volumes: software maintenance downloads, autonomous internet activity by software applications, spam etc.

- Particularly for laptop computer users, but also for PDA and blackberry users there are difficulties in managing the data volumes that are transmitted

- Additional compression of data in the mobile radio network may take place

Data volume charging:

- A mobile operator may round-up data sessions to blocks of e.g. 10 Kilobytes. This means that short data sessions are charged at a higher price than expected

- There is a difference between 'bursty' traffic (many short, low volume events) and streaming-like service (one very long, high volume event). The customer is not aware of the number of data sessions for these events and how this affects the charging of the data volume

6.9 Predictability of usage cost

For voice, the predictability of cost is relatively high. In general, customers are aware that roaming rates are higher than national rates. Usage is charged on the basis of minutes, which is easy for a customer to understand and it is easy to keep track of the usage.

For data this is totally different. First, the customer is generally not aware of the data roaming charges. This is mainly because national usage is usually charged within a bundle, so the customer knows the monthly data costs but not the data volume used nor the price per MB.

Secondly, it is hard for a customer to keep track of the data volume used when abroad. When using a laptop browsing the internet it is very easy to use more than 10 MB per session. Being abroad for a period of 2 weeks and browsing the internet once a day can generate bills for over a € 1.000 at a rate of € 7,50 per MB.

6.10 Future developments

6.10.1 Convergence of technology and services

Traditional (circuit-switched) voice service is the key revenue generator for mobile operators. A service such as SMS has a considerable share in the mobile operator revenues, although mobile data has been a limited contributor so far.

In fixed networks there is already a shift from traditional voice service to internet enabled applications for conversation such as VoIP and Skype. These could include video telephony as is the case with e.g. Skype. Hence, the clear difference between 'telephony' and 'data' is disappearing. With the increasing data transmission speeds this is also likely to happen in the mobile environment. VoIP services and proprietary voice-over-internet application will be applied on mobile broadband networks. Voice is no longer synonymous with 'telephony'. Also data networks become carriers for voice. Regulation for a voice service is difficult to separate from data service regulation. Assuming a circuit switched call of 10 minutes will be compressed (64 Kbps) to a data volume of approximately 5 MB. With the wholesale voice roaming being regulated at € 0,30 per minute, this would be equivalent to a data roaming rate of € 0,60 per MB. This could also be looked at from the data perspective. If a roaming call using VoIP has been executed and 5 MB data volume was required, should the call be more expensive than € 0,60 per MB? What if that same VOIP call could be compressed to 2,5 MB?

Another relevant development in the mobile environment concerns integrated solutions for GSM and Wi-Fi. These allow for using the local Wi-Fi network to send and receive calls using the GSM directory number. Roaming between GSM and Wi-Fi is supported as well as handovers between the networks. This application is called Unified Mobile Access (UMA). Examples of this service are Uniq (Orange) and Fusion (BT).

6.10.2 IMS

The introduction of IP Multimedia Subsystem IMS is a key development in the ongoing process of further development of the concept of 'managed' services in the mobile industry and the initiation of new services in that same industry.

The development of the UMTS standardization came about step by step. The specification of the functionalities both for radio network components as well as for core network components is delivered in releases. The first deployable version was Release 99 that primarily consisted of the WCDMA radio access system.

Release 5 amongst other items contains HSDPA as well as the first phase of the IP Multimedia subsystem (IMS). Release 6 contains enhancements to IMS, HSUPA, Multiple Input Multiple Output (MIMO) antenna systems for higher user data rates etc.

The basic concept of the IP Multimedia subsystem (IMS) is to offer internet services everywhere at any time using cellular network technologies. In IMS the merging of the internet and of the cellular networks takes place. The separation into different domains for circuit switched services (coming from the traditional world of telephony) and packet switched services (introduced by GPRS, and enhanced by UMTS) will disappear. The mobile terminals of today can support virtually any service that can be used via a broadband internet connection such as ADSL. There is a need for IMS for a number of reasons. IMS will provide the improvement of Quality of Service (QoS). It will improve charging capabilities for multimedia sessions and will improve the integration of different services.

UMTS supports a QoS architecture' The following QoS classes are defined for UMTS:

Conversational: Real-time interactive data with controlled bandwidth and minimum delay such as voice-over-IP or video conferencing.

Streaming: Continuous data with controlled bandwidth and some delay such as music or video.

Interactive: Back-and-forth data without bandwidth control and some delay, such as Web browsing.

Background: lower-priority data that is non-real-time such as batch transfers.

In IMS the QoS architecture involves negotiation and prioritisation of traffic in the radio access network, the core network, and in the interfaces to external networks such as the internet. Consequently, applications can negotiate quality-of-service parameters on an end-to-end basis between a mobile terminal and the end-destination.
These capabilities are essential for expanding the scope of supported applications, particularly for multimedia, including (packet) video telephony and Voice over IP (VoIP).

IMS promises a more efficient use of radio resources (because all communication is handled in the packet domain) and cost reduction in the network infrastructure that is fully based on IP building blocks. This allows operators to deliver data and voice services at lower cost.

7   Retail market for mobile data services

7.1   Introduction

This chapter gives an overview of the retail market for mobile data services. It describes the principles for constructing mobile offers, mobile data offers and mobile roaming data propositions.

7.2   Scope of the market and market segmentation

In general, there are 3 main types of mobile services:

- Voice

- SMS

- Data

For all 3 services a distinction can be made between usage within the home country and usage abroad. This study concentrates on data services. These services can be directly offered to the national retail customers or indirectly via either Service Providers/MVNOs/mobile operators (national roaming) or foreign mobile operators to foreign end roaming customers. In general, operators use the following segmentation for data services depicted in Figure 9.

		Retail Market				Wholesale Market	
		Mass Market		Business Market	Business Process Support & Machine to Machine	National: Offered to Service Providers & MVNOs	International: offered to foreign mobile operators
		Pre paid	Post paid				
Data	National						
	Roaming						

Figure 9 Market segmentation

7.3   National data services

7.3.1 General

Mobile operators construct offers to customers based on the following principles:

- Bundling and segmentation

- 'Fixed for variable'

- Cost relation

- Transparency

These principles apply to voice services, but also to data services and will be discussed in more detail in the next paragraphs.

7.3.2 Principles for constructing mobile offers

7.3.2.1 Bundling and segmentation

Operators in general offer a 'bundle of services' to the customers based on the specific needs within a certain customer segment. That bundle of services can consist of: voice, SMS, data, international outgoing traffic, roaming traffic, as well as a low priced handset and premium customer service. For some customers an attractive handset is important whereas for others low international charges are crucial.

Data services are sometimes packaged in attractive rate plans together with voice and SMS services, meaning that data offers are better when combined with voice services. Often the contract duration also determines the rate level.

All voice/SMS services are usually bundled in one subscription for the customer. Rarely do customers take different services from different operators or service providers. This is mainly caused by the fact that a customer wants to be easily reachable on 1 MSISDN number and because it is often financially more attractive to only use 1 operator/service provider. As an exception, the use of multiple SIM cards is seen for example in the ethnic segments in which the customer might use a SIM for making cheap international calls and use another SIM for national calls.

For data services it is easier to have a different provider than for other services. This is especially the case when voice and data use are not integrated in one device. This would, for instance, apply to data usage via a laptop. When both services are integrated in one device (such as in Blackberry devices, smart phones and PDAs) the use of 2 different providers is less likely.

The concept of bundling and packaging is important when evaluating the prices offered for different services. A service can be offered to different customer groups at varying rate levels. This depends on the customer's needs and the competitive situation.

Data rates should not be analysed in isolation. Offers are specific per service and per segment.

7.3.2.2 'Fixed for variable'

Mobile operators offer the customer a trade off between 'low monthly fees combined with higher variable fees' and 'higher monthly fees (often with usage included) combined with low variable fees'.

This principle also applies to data services. National data services are in general charged at the following pricing models:

- Price per MB without any subscription. This is mainly used for prepaid services or for users that only occasionally use data services

- Monthly fee with a certain MB usage included and a separate rate per MB for usage outside of the bundle. In most cases the part of the bundle that is not used within the same month can not be transferred to the next month. More and more operators offer bundles with unlimited data usage. In some cases the transmission speeds for these 'unlimited' bundles are capped. The fact that the bundle will often not be fully used (and in some cases the rate for traffic

outside of the bundle can be more expensive) results in a higher average price per MB than the rate advertised with the bundle. This makes bundle rates more difficult to compare with non-bundle rates.

7.3.2.3 Cost related

Underlying cost drivers are taken into account when constructing an offer. Cost types that can be distinguished:

- Network cost. This cost is usually of a 'shared' nature, meaning that it is not specifically related to a customer or a traffic unit.

- Billing cost

- Marketing and Sales cost. In some cases these costs are directly attributable to a customer. This applies to, for instance, subsidised handsets.

- Traffic related cost. This concerns interconnect and roaming costs that are variable.

- Indirect cost

Operators in general make price plans based on customer segments. These price plans should stimulate market share growth, volume growth and generate a certain average profitability for that customer segment. This means that profitability for certain services offered to the segment can be differentiated as long as the margin targets are reached for the total segment. As an example: international outgoing traffic can be offered to the ethnic segment at very aggressive prices with a relatively low margin. These low margins per minute are then compensated by high volumes of traffic and for instance higher margins on national traffic streams.

When constructing an offer for the different traffic streams, operators in general want all variable/out- of -pocket cost to be covered by a variable rate. This, for instance, applies to interconnect and roaming costs. Primarily this is done to prevent loss- making traffic streams and in the second place to prevent arbitrage. Only in exceptional cases loss-making traffic streams are acceptable when setting the retail prices. This could occur:

- For transparency reasons. This applies when setting international rates. Destinations with different wholesale rates are offered at one retail rate to the customer. Some destinations will generate losses while others generate profits.

- When operators envisage a decline of the out-of-pocket costs and low retail rates are needed to stimulate the market.

For national data usage there are no interconnect charges per MB as there are for voice per minute. In addition to this, a large part of the cost is of a shared nature. Mobile operators have an extensive experience with cost modelling for voice services; partly driven by the interconnect regulation. For data services this experience is not only limited but also more complex because of the issue of licence fees, overcapacity and the different services.

7.3.2.4 Transparency

Transparency is an important driver for an operator's price plans. This can result in a price plan in which operators charge a flat rate to the end customer for various traffic streams that have a different cost structure. Many operators, for instance, offer a flat rate for national calls without making a distinction between calls to mobile and calls to fixed destinations.

Within voice roaming, many operators have now adopted a network independent retail rate. This became possible when the differences between wholesale rates became smaller and operators were more able to direct traffic to their preferred network.

7.3.3 Additional drivers for mobile data offers

In addition to the principles mentioned above there are other aspects that drive data services offers.

7.3.3.1 Market situation

The rates offered for data services and data roaming services should be evaluated in the light of the overall market situation.

At the introduction of GPRS, data service was seen as a premium service for which 'premium pricing' was applicable. The pricing model most used in the beginning was a model based on a rate per MB. Since mobile data had relatively low speeds the total amounts for data invoice stayed relatively low.

When UMTS was introduced, data speeds increased and lap top usage via a mobile network became feasible. This also started the development of offers with a data volume included in the monthly fee. Sometimes operators presented this as 'all you can eat'-bundles. To minimize the risk of extremely high data volumes operators introduced fair use policies, capping the monthly data amounts at, for instance, 1 GB

The introduction of HSPA accelerated this development. Because of the increasing speeds, mobile broadband is now seen as an alternative to fixed broadband. In some cases operators still charge a premium price compared to the rate for fixed ADSL because of the added mobility however, sometimes mobile operators directly compete with the fixed broadband offers. Because of this, the monthly fees have decreased significantly over the past 1-2 years and the data volume included in the bundle has increased to several gigabytes. More and more offers are introduced with an unlimited national usage.

Many operators have now adopted an aggressive approach to domestic data rates (sometimes offering unlimited data access) in order to 'open up' the market and stimulate data usage. Operators can afford to take such an approach because of the overcapacity within the data networks and because the majority of the costs is of a 'shared' nature. Time will tell if these offers are sustainable in the long run considering the underlying cost structures. This will become visible when data networks need to be expanded in order to provide additional capacity. The latter might even lead to a tariff increase for some propositions.

When evaluating national data offers it is important to note that current offers are not necessarily in line with long term sustainable cost levels for offering mobile broadband services. The rates in these offers may be too low compared to these cost levels. If historic costs are also taken into account (including elements like UMTS license fees) then this might result in an even more negative picture. Another element in constructing a mobile data offer is the 'share of wallet'. For instance, mass market customers are prepared to 'reserve' a certain amount of their monthly budget for mobile communications. In the past this was only used for mobile voice. When introducing mobile data, first the customer needed to be convinced of the added value and secondly mobile data services needed to 'compete' for a part of the customers' budget.

7.3.3.2 'Calling party pays principle' and no 'interconnect-regime'

Within data services all data usage is billed to the end customer. This applies to uplink volumes and down link volumes. Within data, the concept of incoming traffic (free to the customer who receives the call) that is charged between operators in an interconnect environment currently does not exist. This is also the main reason why operators are able to make offers with unlimited data usage. As there are no out-of-pocket-costs for termination of traffic, the only costs that operators are confronted with are the costs for using their own network.

7.3.3.3 Service based pricing.

Within the circuit switched technology the main service is voice. Within voice the main commercial differentiations are found in the customer segment and in the various destinations. In packet switched technology, different services are possible on the same bearer technology. This can range from MMS, voice, Blackberry push e-mail, Web browsing, Machine to Machine etc.

The above means that pricing for packet switched service is more complex than for circuit switched voice services.
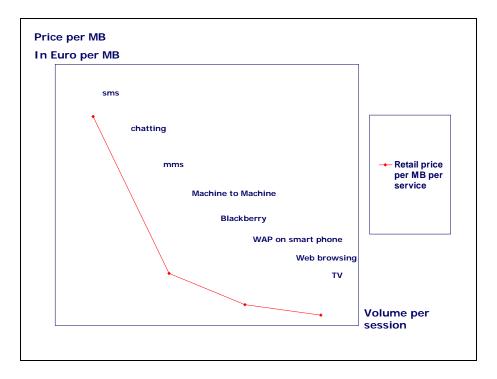
Figure 10 Service Based Pricing

Operators in general offer 2 types of price plans:

- 'Unmanaged model'. Operators offer basic access to the internet/intranet with a price plan priced per MB or a data bundle. This is independent of the services the customer uses on the internet.

- 'Managed model'. Operators use service based pricing for data services. This means that data volumes can be priced differently for different services. Mobile operators aim at offering complete service to a customer instead of only access to the internet. Although all services are offered on the same data bearer technology, some services have a higher value to the

customer than other services and/or the cost involved in creating the service is dependent on the type of service. This concept of service based pricing means that operators charge data volumes depending on the service applied. Often there is also a relationship with session length, in which high volume sessions are priced at a lower price per MB. The concept of service based pricing is depicted in Figure 10.

7.4 Roaming data services

7.4.1 General

Data roaming services are offered as an add-on to the national data services. The main drivers for constructing data roaming offers are:

- cost to purchase the service

- 'fixed for variable'

- Transparency

At the introduction of data roaming, two models were applied:

- The wholesale purchase cost (usually the IOT) + margin percentage

- Tariff 'bands' which individual operators were designated based on their net wholesale charge.

At a later stage operators often introduced substantially lower rates on their preferred networks.

In the last six months operators in general have left the model of pricing differentiated per network and now use only 1 or 2 tariff bands. When operators use tariff bands they usually distinguish between Europe and the rest of the world. In addition, operators have introduced data bundles because of which customers can realise a substantial decrease of the average price per MB. Vodafone, for instance, introduced a day bundle in which the customer receives 50 MB for a daily rate of € 12,00.

7.4.2 Purchase cost

Just as for voice roaming, operators that set data roaming prices need to take into account:

- The wholesale costs charged to them when their customers make use of data roaming. These are usually charged to the operator on a per MB basis. Often billing increments apply. This is explained in more detail in Chapter 9.

- Other costs involved in offering the data roaming service. Examples of these costs are: use of own network, billing cost, bad debt etc.

Although in national data usage the majority of costs are of a 'shared' nature, for roaming data service the majority of costs are variable because operators have to purchase the roaming service from a foreign operator. Operators in general charge each other on the basis of data volume.

7.4.3 Fixed for variable

For customers who are abroad on a regular basis and make use of data roaming services offers are constructed with:

- An additional monthly fee for which the customer gets a lower MB rate in return

- A monthly/daily fee which includes usage (for international usage only, or for both national and international usage)

- A monthly fee for unlimited use (with 'fair use' policy). These type of offers are mainly seen when the volume used is limited and/or of a predictable nature as in Blackberry usage

7.4.4 Transparency

Following the roaming offers for voice, data roaming is increasingly offered in a network independent way. This means that customers usually are charged a standard price irrespective of the network actually used. This especially poses challenges for operators concerning traffic steering and negotiations with non-preferred partners.

7.4.5 Service based pricing

Operators also have the option to differentiate in rates for data roaming based on the service used. For instance, some operators have a different roaming rate for Blackberry usage.

7.4.6 Group offers

From a cost perspective groups of operators have the possibility to make offers in which they offer data roaming at rates closer to the national data usage tariff. This is because the wholesale charges are 'internalised'. An example for this is the 'Roam like home' offer by H3G.

However, most groups offer data roaming at a price level higher than used for national data usage. Groups can have different reasons for this. Some reasons might be:

- The customer perceives data roaming as a service that adds value to him. This value translates into the price level.

- Positioning in comparison with alternatives like Wi-Fi or offers from competing mobile operators.

- Transparency for the customer if an operator does not want to distinguish between different operators in a country or in different countries.

7.5 Data services offered by Service Providers and MVNOs

Mobile operators offer mobile data services directly to the retail market via their own sales channels but also indirectly via Service Providers and MVNOs. Service Providers and MVNOs currently focus on voice Services. The data services they offer are usually very similar to the services offered by mobile operators.

Service Providers in general buy services from the mobile operators on a retail minus basis. Based on the retail offers from mobile operators, the Service Providers get a certain wholesale discount on the service sold.

MVNOs usually are in a different model. They agree on a wholesale charge per MB and then package this in their own services. In general, the wholesale charge paid by MVNOs will be below the net rate (retail-/- wholesale discount) paid by Service Providers to mobile operators.

8 Wholesale market for mobile data roaming service

8.1 Introduction

In order to be able to offer retail data roaming services, mobile operators have to obtain 'roaming access' to foreign mobile networks. This is similar to the situation for voice services.

This means operators have to agree between each other on the availability of data roaming services to the retail customers. As is the case with voice this is often bilaterally agreed on. GPRS/UMTS roaming can be seen as an add-on to basic GSM roaming both from a service and a contractual perspective.

From a commercial perspective this is not seen as a separate market for which separate negotiations are conducted. In general, the agreement on data roaming rates is part of one instance of negotiations conducted for the total of roaming traffic exchanged between operators. These negotiations include: voice services, SMS services, roll out of services, quality of service etc.

Agreements for data roaming services started with the launch of GPRS Roaming in 2002.

At the time of the launch of GPRS Roaming it was not common to negotiate data roaming rates. This started a couple of years later and was driven by competitive pressure from the retail markets and the introduction of higher data speeds via UMTS.

When a mobile operator wants to deploy GPRS/UMTS roaming (both for visiting subscribers and its own subscribers) the following pre-requisites have to be fulfilled:

- Availability of relevant technical infrastructure like SGSN and GGSN.
- Availability of IP connectivity. This is usually achieved via GRX providers.
- Billing solutions like CDR/TAP-file generation and data clearing facilities
- Standard IOT
- IOT negotiations
- GPRS/UMTS contract
- Testing and implementation
- Traffic steering

8.2 Wholesale charging principles

8.2.1 Roaming regime versus interconnect regime

As is the case for voice, operators charge each other for the total of the services used by foreign retail customers on the network abroad. In the contractual relationship for data roaming all data traffic executed by the customers is charged to the home operator who subsequently charges this to the retail end customer. This applies to both the upstream (uploading data) and the downstream traffic (downloading data). In this respect voice services differ from data services. In

voice services a customer can make outgoing calls and receive incoming calls. Europe uses the concept of 'calling party pays'. The customer that receives a call when in his home country does not pay for this. Operators charge each other for the termination of calls within the interconnect regime. When a customer receives a call while roaming, this is settled between operators via the interconnect regime and in most cases there is no separate charge for these calls under the wholesale roaming contract.

For data services the concept of incoming calls does not exist at the moment. The cost for all data traffic is charged to the end-user. The principle of interconnect charges for data traffic between operators is seldom seen.

8.2.2 Standard IOT Elements and structure according to GSM-A rules

As it the case for voice, operators announce a standard 'Inter Operator Tariff' for data that - on a non discriminatory basis- will apply to all foreign operators that want to make use of the data roaming services. The IOT is communicated in the operator's AA 14, which is part of the overall contract between operators for roaming.

The IOT rates can for instance be differentiated based on:

- Days of the week

- Time during the day

- Uploading and downloading data

- Different APNs used. This creates the possibility to differentiate between different uses of data. For instance, web browsing can be rated differently from sending an MMS. A disadvantage is that operators need to maintain lists of APNs for all foreign operators and the services for which these APNs are used. Moreover, it will be difficult for operators to check if an APN is actually used for a particular service. Operators have the possibility to offer certain APNs for free.

- The volumes within a session: the so called 'step-pricing'. Operators can introduce different rates for different volume bands within a session. This creates the possibility to differentiate between small and large data sessions. The principle of step-pricing is further explained in Chapter 8.2.3.

- Quality of Service differentiation. This could be done on the basis of parameters like: delay, mean/peak throughput, priority etc. Nowadays, operators most dominantly offer a 'best effort' service.

The possibilities for differentiation in the IOT are agreed within the framework of the GSM-Association's "Billing and Accounting" rules. Operators can define their IOT on the basis of:

- Volume of a session : KB or MB

- Time length of a session in minutes

Operators can also charge for setting up a PDP context. This effect is similar to a call set up charge for voice. As in voice, the billing increments are relevant within data services. Operators can use:

- First increments; the minimum amount of KB to be charged for each session

- Subsequent increments. When an operator for instance uses 10 KB increments, this means that a session of 71 KB will be rounded up to 80 KB.
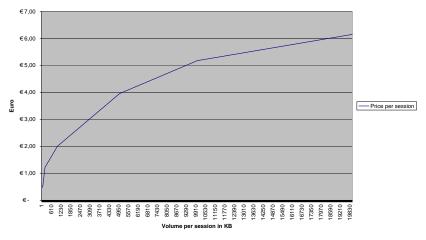
Increments can have a substantial effect on the average price per MB, depending on the traffic pattern. In general, the effect will be that smaller sessions have a higher average price. A session of 20 KB priced at € 10,00 per MB with no increments will cost € 0,19. When priced at the same rate but with a first increment of 50 KB this session will cost € 0,49.

8.2.3 'Step-pricing'

In 'step-pricing' operators divide a data session in usage blocks. Each block of usage inside the session can have a different price per MB and a different billing increment. An example of a 'step-pricing' model is as follows:

Step size (in KB)	Cumulative volume (in MB)	Charging increment (in KB)	Rate step (in € per MB)	Charge per step (in €)	Cumulative charge (in €)
50	0,05	50	10,00	0,49	0,49
150	0,20	10	5,00	0,73	1,22
800	0,98	10	1,00	0,78	2,00
4000	4,88	10	0,50	1,95	3,96
5000	9,77	10	0,25	1,22	5,18
	>9,77	10	0,10		
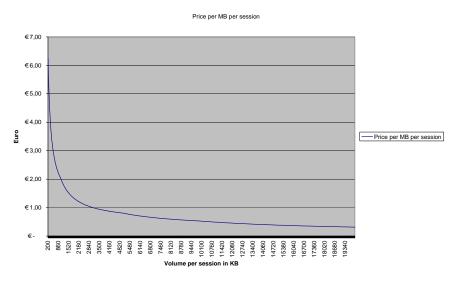
Figure 11 'Step-pricing in the wholesale market'

Main parameters that determine the total price for small data sessions:

- Price per MB in the first block (s)

- Billing increments used in the first block

Main parameters that determine the total price for large data sessions

- Price per MB in the last block

- Volume at which the last block starts

'Step-pricing' brings the principle of service based pricing (since services often have a typical session length) to the wholesale market. Operators use this instead of the more difficult APN differentiated pricing. 'Step-priced' wholesale charges give an operator more possibilities to offer attractive retail rates for high volume sessions.

8.3 IOT structures and levels seen in the market

The majority of operators have an IOT that is based on the data volume being transferred. There are two main reasons for this:

- It fits the principle of 'always on line'; the customer can stay connected to the network and is only being charged for the actual data transferred

- The use of network capacity (and also the cost) is mainly driven by the volumes of data sent and received by the customer

In general, European operators use 2 models:

- A flat fee per MB. Sometimes in combination with a first increment/PDP activation charge and with subsequent increments (the so-called unitisation) of for instance 10 KB

- 'Step pricing' per MB. A session is divided into different steps and each step is charged at a different rate per MB. Often this means that high volumes are charged at a lower rate per MB.

Most operators started with a flat fee per MB, combined with increments. Some operators moved to 'step-pricing' per data volume.

There is a wide variation seen for the first increments. Some operators do not use them, while others have a first increment of 100KB.

In Europe it is estimated that in 2007 the average standard IOT for data roaming varies between approximately € 5,00 and € 10,00 per MB. This not only depends on the price per MB but also on the data traffic profiles. Because of the increment charges, operators with larger volumes of high speed data sessions may have lower average IOT levels than operators which have smaller volumes of high speed data sessions

On a per session basis the spread is substantially more extensive. This spread is caused by the billing increments operators use or by the 'step-based' pricing model. For high volume laptop sessions the standard IOT charge might be as low as € 2,00 per MB while for a small volume MMS session (in a model with a large first increment) this could go to levels well above € 20,00 per MB.

Over recent years, some operators have not changed their IOT and have left it at the level it was at when GPRS Roaming was introduced. Problems arising from high IOT levels are often solved in the general IOT negotiations. Other operators have achieved a decrease in their average standard IOT rates because of the introduction of a 'step- pricing' model.

In some cases, operators belonging to the same group have a similar standard IOT structure or even the same standard IOT level. However, this does not generally apply. Of course the discounted IOT rates within a group can be of the same level and/or structure.

8.4   IOT negotiations

8.4.1 History

As for voice, operators have the possibility to negotiate on the standard IOT rates.

Within voice the possibility to negotiate lower rates has been created by the fact that operators can perform traffic steering, meaning they can direct the traffic to a certain network in return for better commercial conditions. Negotiations for data are closely connected to the voice negotiations. In most cases there are no separate negotiations for data traffic. The total package of roaming traffic is negotiated.

Contrary to voice roaming negotiations in which rates often depend on the total volumes sent to the visited operator, for data, in general, a volume independent rate is agreed amongst operators.

When data services were introduced they were only a very small part of the total negotiated value. This meant that the focus in the negotiations was mainly on voice traffic. In the negotiations back then a lower rate of € 0,01 on voice was often preferred over, for instance, a 50% discount on the GPRS IOT.

In addition to this, operators showed a reluctance to negotiate lower rates on GPRS. This was due to:

- Traffic balances. Operators in a net-receiving position are inclined ,from a financial perspective, to keep data IOT rates at high levels

- The uncertainty operators felt concerning the development of data services. Mobile data were seen as the 'next growth curve' for the mobile industry. In order to preserve the value of the business, it is not unusual that operators keep the rates at relatively high levels during the early stages of such a growth cycle.

- The high cost connected with the roll out of UMTS and the payments for UMTS licenses

The above factors led to a situation in which there were relatively high wholesale data roaming rates that had a flat structure (meaning not differentiated per service). Since retail roaming data rates are based on the negotiated wholesale rates, this also created a 'base' for the retail roaming data rates.

When UMTS and UMTS Roaming were introduced in 2004/2005 the data rates became more important in the roaming negotiations, because operators were pushed to introduce improved roaming rates to the customers. In particular this was an issue for laptop computer users. Even operators in a net receiving position were pushed by their retail business clients to lower the wholesale data rates. This increased focus does not take away the fact that the financial relevance was still minor.

8.4.2 Negotiations with preferred and non-preferred partners

Until recently, the negotiations for lower data rates mainly happened between operators who have a 'first preferred' relationship. For different reasons these negotiations are also extended to other operators in a country. The main reasons are:

- The first preferred partner for voice traffic does not always provide a sufficient data network coverage/quality. In order to offer the customer the right service quality it is necessary that the customer can also access the data networks of the other operators.

- The differences in rates are too high to effectively translate this into a retail offer. For voice, the difference between the rate for a preferred partner and a non-preferred partner in the past could be as high as a ratio of 1:4. After the regulation this has come down to levels such as 1:1,5. This created the opportunity of network independent retail pricing. For data, the ratio between the wholesale rate on preferred and a non-preferred partner could go as high as 1:20. Combined with less effective traffic steering, this will make attractive retail pricing difficult. If, for instance, the first preferred operator offers a wholesale rate of € 0,50 per MB and the others offer a standard IOT of > €10,00 then a network dependent retail rate is difficult. This is because retail charges far above € 10,00 per MB are not accepted in the retail market. On the other hand a weighed rate for all operators is also difficult because of uncertainties regarding the traffic steering effectiveness.

If the voice traffic exchanged between non-preferred partners is low it will prove difficult to negotiate sufficient low levels for the data traffic.

For voice an operator can afford to only negotiate with the preferred partners assuming there are high levels of traffic steering efficiency. Not all operators can afford this position for data traffic.

8.4.3 Negotiated IOT: structure and level

Within the IOT negotiations for data traffic three structures are seen:

- Flat fee per MB with no increments

- percentage discount on the average price per MB

- Step based pricing implemented as a new standard IOT in TAP file. Such a negotiated wholesale structure can initially lead to the same average MB rate as the other 2 models, but the main advantage is that it enables more attractive retail offers for large volume data sessions. This will stimulate usage of these large volume sessions and will over time result in lower average rates than the other 2 models. It is expected that the 'step-price' discount offers will be adopted by an increasing number of operators.

It is important to distinguish between net paying, net receiving operators and operators belonging to a group.

8.4.3.1 Net receiving operators

Operators that are net receiving on data traffic generally strive for a high IOT level. This generates high wholesale revenues. Keeping those IOT levels high limits these operators in bringing attractive data roaming rates to the retail market. Sometimes, net receiving operators take a different approach and agree low bilateral wholesale rates in order to use these to create attractive retail data offers; the loss on wholesale revenue should then be compensated by increased retail revenues.

8.4.3.2 Net paying operators

Net paying operators strive for a wholesale rate that is as low as possible. For 2007 it is estimated that between preferred partners the level of the negotiated IOT is typically between € 0,50 and €1,00. In exceptional cases, the negotiated IOT may be below € 0,50.

With non-preferred partners this is much more difficult. Often there is no or only a limited discount realised in these negotiations. However, Vodafone announced in 2007 that its wholesale offer of € 0,50 per MB is available to all operators as long as it is agreed on a reciprocal basis. Combined with a limitation in traffic steering effectiveness this might lead to high average wholesale rates per MB for certain operators.

It is estimated that for 2007 the average negotiated wholesale roaming charge for the European region is between € 2,50 and € 5,00 (depending on the region, the networks used, the effectiveness of traffic steering, the volume characteristics, level of 'internalisation' of traffic and the negotiation power).

At the start of GPRS the average wholesale charges paid was close to € 10,00 per MB. This shows that wholesale charges have decreased over the years by 50-80%.

8.4.3.3 Group operators

In general, the impact of groups and alliances on data traffic is similar to that on voice traffic. This means there is a strong tendency to send the traffic to the network belonging to the group or the alliance. This is mainly because of financial reasons and the ability to offer seamless services.

This means that operators within a group or an alliance tend do business with each other. Their business with other independent operators tends to be limited. The same applies to independent operators that have the tendency to do business between them.

This 'compartmentalising' of the market, together with the consolidation between mobile operators leads to a decrease in competition in the wholesale roaming market.

Within groups wholesale data rates are agreed amongst each other. Different groups can have different rules to determine these intra-company rates.

8.5 Traffic steering

8.5.1 General

Although the volume of data traffic sent to an operator might not be the main driver for the IOT rate that can be negotiated traffic steering for data is still very important for 2 other reasons:

1. Quality of service; make sure the customer uses the network best suited for the services they want to use. Not all applications can be served on all networks. For instance, customers using a laptop card are best directed to a network offering HSPA technology. Devices might have certain preferences that automatically direct the user to a certain network. For instance, UMTS devices might preferably search for a UMTS network in order to serve the customer in the best way possible.

2. Bring down the average wholesale rate paid in a certain country. Since retail rates for data are now usually network independent, this means that the country average forms the basis for the retail departments to base their offer on. This is even more important in a situation in which

there is a large differentiation between the rates paid on a preferred partner in comparison to the rate paid on a non-preferred partner. For example:

- 90 % of all data traffic is carried via the preferred operator at a rate of € 1,00 per MB and 10% is handled on the non-preferred partners at a rate of € 10,00 per MB. This leads to an average rate of € 1,90 per MB

- 50 % of all data traffic is carried via the preferred operator at a rate of € 1,00 per MB and 50% is handled on the non-preferred partners at a rate of € 10,00 per MB. This leads to an average rate of € 5,50 per MB which is almost 3 times higher

The traffic steering effectiveness can substantially differ per country. When the first preferred partner for voice has HSPA technology available with sufficient coverage the traffic steering efficiency can be close to the one for voice. If this is not the case, the efficiency can be substantially lower because a larger part of the traffic needs to be carried via the non-preferred networks. This is the reason why IOT negotiations with non-preferred partners are more important for data than for voice.

8.5.2 Availability of GPRS/UMTS/HSPA technology

voice services can generally be handled via all available GSM networks. Among the networks there might be differences in quality and coverage. For the negotiations this means that all networks are potentially competing for the visiting voice traffic.

For data services this situation is different. Each operator can be at a certain stage for the deployment of the network for data services. The different stages are: GPRS, EDGE, UMTS, and HSPA. The customer experiences the difference between these stages as a difference in transmission speeds available. For instance, HSPA allows a data speed of 1,8 Mbps and higher.

Certain mobile services require high transmission speeds. For instance, laptop usage in general requires speeds above 1,5 Mbps. This is comparable to the user experience that customers have when using their fixed line for internet usage.

Not all networks in Europe have HSPA rolled out. For some of these operators the roll out of HSPA technology is uncertain. Moreover, there are also operators who have a limited coverage with their UMTS networks; they only fulfil the coverage requirements according to the UMTS spectrum license requirements. HSPA is not required from a license perspective.

For the roaming negotiations this means that not all operators can compete for the whole volume of data traffic from visiting subscribers. For instance, a foreign operator that has a non-HSPA operator as first preferred partner for voice traffic can only send limited amounts of data traffic to that partner because there is no HSPA available. This will only be possible for applications that need low transmission speeds. For applications needing higher speeds the traffic will need to be handled via a HSPA operator. To negotiate rates for relatively small volumes of data traffic will not be easy. This could lead to a situation in which an operator is faced with the following choices:

- Offer low transmission speeds at a reasonable rate to the end customer

- Offer high transmission speeds at rates that might prohibit the customer from making use of the service

- Advise the customer to make use of alternatives like Wi-Fi if there is coverage available

In the end this might result in a situation in which the home operator is not able to make a competitive roaming offer for applications that require high transmission speeds. In addition to

this, the operator might not only lose this customer for data roaming traffic, but also for the national data services or even for all services. This might especially be true for customers at the high end of the business market.

Of course another alternative could be to switch all voice and data traffic to an operator offering HSPA in order to be able to offer competitive data roaming rates. This situation makes operators that do not offer HSPA vulnerable to the loss of visiting roaming traffic.

Because not all operators offer HSPA services, it can be concluded that in the wholesale market for data roaming there is less choice than in the wholesale market for voice roaming. This is partly compensated by the fact that customers/operators have the alternative of Wi-Fi available.

8.6   GPRS/UMTS contract

In order to facilitate data roaming, operators have to update their GSM roaming contracts. Basically this can be done in two ways:

- Updating the existing agreement by signing an Addendum (AA31) to the contract

- Implementing a new technology neutral AA12/AA13 that includes GPRS and UMTS

In addition to this, it is necessary to update the AA14 with the relevant commercial information and the IR 21 with the relevant technical information.

The standards for these agreements are managed by the GSM Association. In general, operators use these standard contracts; however operators are free to negotiate changes on these contracts bilaterally.

9 Translating negotiated wholesale charges into a retail data roaming offer

9.1 Introduction

In the retail market for mobile data services a high differentiation can be seen between the MB rates for the different services. Data services are often offered in a bundle.

An MMS of 20 KB priced at € 0,50 per MMS has an equivalent price per MB of € 25,00 per MB. An SMS sent via the packet switched network of 3 KB priced at € 0,10 has an equivalent price per MB of € 34,00. For some machine to machine solutions with low traffic volumes the average rate per MB might even be higher. On the other hand, there are MB rates below € 0,01 in web browsing bundles with multiple Gigabytes included.

In addition to this increased differentiation, the introduction of HSPA has also accelerated the decrease of retail data rates for services requiring high transmission speeds.

The prices in the wholesale market for data roaming followed the downward trend mentioned above. However, the negotiated rates in the wholesale market did not follow the trend of the differentiation of rates. This differentiation in service (via 'step-based' pricing) on the wholesale side did not start until 2008.

Assuming that mobile operators want to translate the trend in national data prices into similar propositions for data roaming it is required that the wholesale data roaming rates facilitate such an approach. At least until 2007, the wholesale rates were not 'connected' to the retail developments.

9.2 Structure of the data roaming retail propositions

Partly driven by the voice roaming regulation most operators have moved to a price structure for roaming with the following characteristics:

- EU rates versus non-EU rates (sometimes further differentiated)

- Operator independent. This removes the hassle of switching networks for the customer

For transparency reasons it is likely that data roaming offers will be structured in the same way. In the European perspective this means that the wholesale rates negotiated with all European operators will be relevant for constructing the retail offer. The level of relevancy will be dependent on:

- Volumes in a certain country. Operator can afford short term loss-making wholesale data roaming rates in countries in which they have low volumes.

- Volumes on a certain network in a country. An operator with a high data traffic steering effectiveness can afford to have short term loss-making traffic streams on the non-preferred networks.

This applies to independent operators and to operators belonging to a group. Even groups with a large footprint can have difficulties in constructing a transparent data roaming retail offer if they

miss certain key destinations or if the operators within their footprint have no HSPA or a poor UMTS coverage.

9.3   Ratios between wholesale and retail rates for roaming

Market signals indicate that the average net wholesale rate ranges between € 2,50 and € 5,00 depending on the region, the networks used and the negotiating power of an operator. In general, this average is service/session length independent.

The ERG report on roaming [1] shows that the average retail rate for data roaming services is close to € 5,24 per MB. This is depicted in Figure 12.
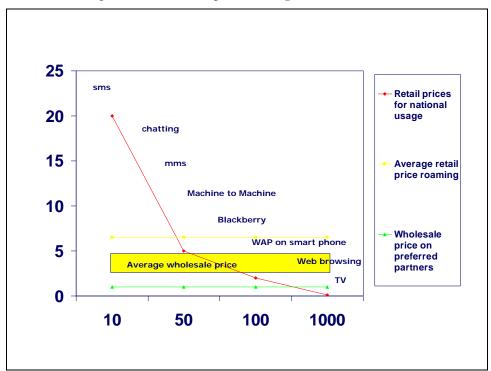
Figure 12 Average wholesale price

In the voice regulation the gross margin between wholesale and retail in relation to the regulated retail rate is approximately 40%. Assuming an average wholesale rate of € 3,00 per MB and an average retail rate of € 5,24 per MB the gross margin is also close to 40%. When an operator wants to have gross margins similar to those for voice roaming and lower the retail data roaming rates at the same time this implies that the wholesale rates need to be lowered and/or further differentiated based on the service used.

This can also be viewed from a different perspective. After the voice roaming regulation was put into place, the ratio between the national retail rate and the roaming retail rate is 1:3 when assuming a national rate between € 0,15 and € 0,20 per minute. Taking for example a national data rate in a high volume bundle of € 0,02 per MB and assuming the same 1:3 ratio then the retail data roaming cannot be more expensive than € 0,06 per MB This is far lower than the lowest retail data roaming rates operators currently charge; rates vary between € 0,24 per MB for the Vodafone day bundle and € 1,00 per MB (when used in a roaming bundle) A gross margin of 40% would require –in this example- a wholesale data roaming rate of € 0,035 per MB

Basically there are two options to realise this:

1. A very substantial decrease in the flat rates agreed upon with all important roaming partners. Operators might be reluctant to move to a low flat rate because this might make them vulnerable to arbitrage in their national retail markets on services that are priced at relatively high per MB rates at retail level. For instance, a low flat wholesale roaming rate can enable an operator to introduce a Blackberry offer on a foreign market. This arbitrage risk is higher for data than for voice because for voice the national MSISDN issue has to be solved in order to be reachable. The revenue implications might also keep operators from moving to a flat rate wholesale rate.

2. A 'step based' rate with all important roaming partners that facilitates high volume sessions

These different models are shown in figure 13.
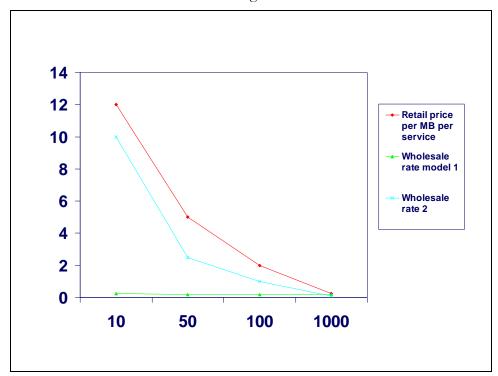
Figure 13 Retail vs. Wholesale pricing

It is important to note that these issues in wholesale pricing exist to a lesser extent for operators that belong to a group that has a large European footprint.

9.4 The impact of lower wholesale rates on data roaming retail rates

When wholesale roaming rates are lowered and/or further differentiated for service/session length (this might even lead to a higher wholesale rate for short sessions) the following is likely to happen to the data roaming retail rates:

High volume sessions as in laptop usage

Operators will bring the retail roaming charges more 'into line' with the national data charges, taking into account the value that the roaming functionality represents to the user and the alternatives in the marketplace like Wi-Fi.

This might substantially increase the data roaming usage, offsetting the effect of lower prices. This price elasticity can make the decrease of retail data roaming rates an easy business case for a mobile operator.

Facts that could support this high elasticity are:

- Business customers that travel abroad make frequent use of Wi-Fi services when in airports, hotels, restaurants, congress centres or on public transport. The use of these services is mainly driven by price for the service, predictability of the invoice, data speeds offered, and ease of use (especially in situations in which mobile operators have launched Wi-Fi roaming services)

- High penetration of lap tops both in the business and mass market segment.

- Usage and service limitations companies have set their employees.

- The need for customers to stay easily connected with home while roaming abroad.

Low volume sessions

The retail rates need to be matched with the wholesale rates for these sessions (will be higher in a 'step' pricing model than in a flat rate discounted IOT) and with the national rates for these services. In addition the value this service represents to the customer is taken into account. The above will not necessarily lead to a decrease of the retail roaming rates. It might lead to a situation in which billing increments for roaming are harmonised with the increments for the national service. A further decrease of these rates needs to be mainly driven by retail market competition.

9.5 Substitutes

For voice roaming there are almost no alternatives available. This is mainly because there is the need for the customer to be reachable on their mobile phone number.

For data the customer has more alternatives:

- Customers who make frequent use of data roaming services can use another mobile provider for this if their provider for voice services does not provide an attractive enough data roaming offer. This could even be a foreign mobile provider.

- Wi-Fi services. The use of data services (in particular for a laptop computer user) is often of a static nature; this means the customer is at a certain location and does not use it 'on the move'. In this case, Wi-Fi can be a very good alternative. Wi-Fi offers coverage in all the major airports, hotels, conference centres etc. The speed of Wi-Fi is comparable to ADSL and the costs are relatively low and usually MB independent. Accessibility and ease of use for mobile users has increased now that more and more mobile operators offer Wi-Fi roaming. This means that customers can access multiple Wi-Fi locations with one username/password and can get the usage costs invoiced on their own mobile bill. In some cases authentication can even be done on the basis of the SIM-card.

Rates for Wi-Fi typically vary between € 5, 00 and € 10, 00 for a 1 hour usage and between € 10,00 and € 20,00 for a full day usage. Some hotspot owners like hotels or cafés might decide to

offer Wi-Fi for free in order to attract customers. Wi-Fi usually does not have limitations on the data volume transmitted.

It is important to note that the Wi-Fi service is often offered by either the fixed and/or mobile operators in a certain country.

10 Price analysis for national data services

10.1 Introduction

In this chapter the results of research done into national data rates are provided. The aim of this analysis is to give an overview of the structure of the market offers, the conditions and the levels offered.

The following countries are part of the analysis:

1. The Netherlands

2. France

3. Austria

4. United Kingdom

5. Italy

For each country the offers of all the operators are incorporated in the analysis.

10.2 Structure and conditions

In general, mobile operators offer data propositions for:

1. Web browsing

- Usually offered in a monthly data bundle. Together with the introduction of HPSA, bundles of multiple Gigabytes have been offered. If the customer does not use a bundle the use is generally charged at a price per MB

- The proposition is sometimes differentiated for the transmission speed offered. Sometimes operators offer HSPA as an add-on subscription

- Unused data volumes from one month are usually not transferable to the next month

2. Smart phone/PDA. Usually offered in a monthly data bundle included. The proposition is sometimes differentiated for the transmission speed offered. If usage is not offered in bundles, operators sometimes offer it on the basis of a charge dependent on the volume consumed within a session

3. Value added services like music downloads, mobile TV etc. Bundles of data usage are also common for this

4. Blackberry. Offered in a bundle with unlimited usage

5. Machine to Machine services

An increasing number of operators offer mobile data on an 'unlimited basis'. Often this is combined with a fair use policy or with a cap on the transmission speeds (for instance for PDA/smartphone usage). Some operators offer time based bundles; in some cases combined

with a fair use policy on the data volume used. Some operators add the use of Wi-Fi in the data bundles. Not always do operators allow the use of services like Skype. More often than for voice the offer to the mass market is the same as for the business market. The only difference is VAT.

10.3 Data session charging

Data volumes are measured in volumes of bytes used. The volume used does not necessarily have to be the same as the volume charged to the end customer.

Operators in general work with billing increments. They distinguish:

- First increment. This represents the minimum amount to be charged for each data session. This, for instance, can be 10 or 20 KB. This has an effect comparable to a call set up charge within voice. If a customer has multiple small data sessions this results in a relatively high price per MB.

- Subsequent increments (rounding). Each session is rounded to the nearest multiple of for instance 10 KB.

10.4 Rate levels

With the introduction of HSPA, more and more operators now introduce aggressive data offers for web browsing. Users that only occasionally use data, pay data charges on a per MB basis. For the business market customers the rate for this would typically be between € 0,50 and € 1,00. In some cases, mass market customers pay a substantially higher rate per MB. Operators often combine this with the use of increments of for instance 10 or 20 KB.

A typical charge for a Blackberry subscription would be between € 10,00 and € 20,00 per month. A user using 5 MB per month would then pay on average between € 2,00 and € 4,00 per MB.

Subscriptions for web browsing now start at levels of € 15,00 and € 20,00 per month for bundles with for instance 250 MB included and range to above € 50,00 per month with multiple Gigabytes of usage included. If the bundle is fully used, the rates per MB in these propositions can range from € 0,10 per MB to levels below € 0,01 per MB.

Rates for PDA/smart phone bundles are typically between € 10,00 and € 20,00 per month. For the mass market it is sometimes lower but then transmission speeds might be lower or the usage included smaller.

Often, operators offer lower rates when combined with a voice subscription or if a contract of 1 or 2 years is agreed on.

Rate levels can differ per country based on the specific market conditions. The presence of a 3G only operator or the competition with fixed ADSL providers might be important elements in this.

11 Pricing for roaming data services

11.1 Introduction

In this chapter results of research done into data roaming results are provided. The aim of this analysis is to give an overview of the structure of the market offers, the conditions and the levels offered.

The following countries are part of the analysis:

1. The Netherlands

2. France

3. Austria

4. United Kingdom

5. Italy

For each country the offers of all the operators are incorporated in the analysis.

11.2 Structure and conditions

In general, mobile operators offer data roaming in the following propositions:

- Fee per MB combined with increments
- Data bundle at a monthly fee

Operators usually do not differentiate per country or per network used. If they do, then usually it is between roaming usage in Europe and roaming usage outside of Europe.

Some operators offer daily bundles; for instance Vodafone Netherlands offers a daily bundle for € 12,00 with 50 MB included for the business market. The customer will not be charged for more than 12 days a month, making the roaming cost for the customer much more predictable.

Some operators offer monthly bundles in which both national and international usage is included for a certain number of MB. For instance, Vodafone Netherlands offers the International Super bundle in which national usage is offered at € 0,03 per MB and international usage in countries where a Vodafone network is present at € 0,30 per MB.

Blackberry is offered either at a rate per MB or within an 'international' bundle with usage included (sometimes subject to a fair use policy).

H3G offers a 'roam like home' proposition in which data usage abroad on H3G networks is charged at the same rates as the customer has for national usage.

11.3 Rate levels

For data roaming not within a bundle proposition a typical roaming charge would be between € 5,00 and € 10,00 per MB. In exceptional cases it can be above € 15,00 per MB.

Offered within a bundle, the rates offered are usually around € 1,00 per MB or even somewhat lower. Vodafone's daily bundles offer a rate of € 0,24 per MB if the bundle is fully used.

The ERG analysis (published 17th January 2008) shows an average retail roaming rate in Q3 2007 of € 5,24 per MB within Europe. Since the start of GPRS roaming these average retail rates have been substantially diminished. This analysis also shows the variations among the different EU countries; the lowest average being below € 4,00 per MB and the highest average being above € 10,00 per MB. The differences in these averages can be due to traffic patterns/services used or due to differences in the rates charged to the customers.

11.4 Group offers

For groups of operators the situation is different. If wholesale charges were 'internalised' group members would only have to take into account the actual cost involved in data roaming and be able to offer data roaming services at levels closer to the national data rates. For instance, the H3G group even offers data roaming on Group networks to her the customers at national data price levels. If the footprint of a group is small and major countries are missing then, of course, it is more difficult to introduce such an offer when the home operator applies country and or network independent retail prices.

Although groups have these possibilities, because of cost involved in setting up data roaming, competition and/or value offered to the customer, data roaming is not automatically offered at rates close to national rates.

12 Business processes national and roaming data services

This chapter contains a short description of the key business processes for national data services and roaming data services:

12.1 General business processes

- Network provisioning

Provisioning of data services for a subscriber of a mobile network takes place through the service activation process of the mobile operator. The provisioning for national data services and roaming data services is essentially the same. As part of the provisioning process a subscriber should be able to use services in a visited network

- Retail billing and invoicing

End user billing (charging) and invoicing for both national data services and roaming data services is executed by the home mobile operator that the subscriber subscribes to. Retail billing for roaming data service requires data session details (usage data) that need to be retrieved from the visited network operator. This can be done using TAP procedures as described in chapter 12.4. Alternatively, usage data can be derived from the GGSN in the home network. The latter method is more reliable and secure, but is only applicable in case home routing is applied.

- Customer Service

Customer Service provides a helpdesk for product, technical and commercial support. Usually, the customer service can also be reached from a visited network while roaming.

- Interconnect and wholesale billing

This business process concerns the billing of network operator services to and from third parties such as interconnected networks, transit networks, SMS broking (for interworking), Mobile Virtual Network Operators (MVNOs) and service providers.

12.2 Roaming specific business processes

This chapter describes the specific key roaming business processes:

- Roaming network contracting

This concerns the negotiation with roaming partners to build roaming agreements between the networks. Roaming agreements usually cover several services such as voice, SMS, and data

- Roaming testing

This concerns bi-lateral tests of the roaming service between networks. Standardised pre-defined test procedures are in place (defined by the GSM Association) to test network interworking as well as the exchange of billing (TAP) details. Such tests are the IREG test for technical interworking and the TADIG test to test the billing.

- Roaming roll out

After tests are finalised and completed a commercial launch letter is signed and a launch date is agreed between the roaming parties. For launching UMTS some operators perform additional tests.

In most cases, operators launch the GPRS Roaming service if they can offer coverage in their main roaming destinations. An example of a roll out plan could be:

1. One network in all the main destination countries. This could, for example, be the preferred network for voice in these countries

2. Roll out a second network in the main destination countries in order to provide better coverage/quality

3. Roll out first and second networks for all the other destination countries

This roll out plan will put some challenges to traffic steering. Customers that use data services should obviously be directed to the networks that offer data roaming possibilities, but these are not always the networks that are preferred from a voice perspective. Some operators even prevent their (data) customers from registering with networks without data roaming functionality. This challenge is also apparent in case of the roaming laptop users in destination countries where there are limited or no networks providing UMTS and HSPA services.

- Roaming billing (wholesale)

The usage of data by visiting subscribers and their access to a network will need to be charged to the home network operator on a wholesale basis. Roaming data services are in this respect similar to roaming voice services.

- Roaming support

This concerns the execution and management of the roaming contracts i.e.: solving of network and billing problems, reconciliation of roaming costs charged by roaming partner networks and revenue assurance. This roaming support process exists for both voice and data services

- Fraud and high usage detection

As part of a roaming agreement mobile operators put in place procedures to detect high usage by roaming subscribers in visited networks. These procedures look into fraud and misuse as well.

12.3 Charging of Data services

For national data services the mobile operators need a mechanism to count the amounts of data transferred and to calculate these charges. The calculation is based on detail records (usually referred to as Call Detail Record, CDR) that are generated in the network components such as SGSN and GGSN. The CDRs generated are collected in a billing system for rating and billing and invoicing.

Mobile operators may have different implementation options. The usage rating could be based on the SGSN detail data, the GSSN detail data, or the combined SGSN and GGSN detail data.

In case of prepaid service the implementation options are different since for prepaid services it is necessary to validate before and during a data session if sufficient credits are available to start and continue the data session. A solution would be to use real-time session control (e.g. based on CAMEL). However, real-time session control and billing could also be managed from the GSSN in the home network, in case home routing is applied.

12.4 Charging of roaming data services

In case a data session is executed while roaming, part of the detail records is generated in the roaming network (since the SGSN of the roaming network is used). This CDR can be collected by the home network. The common way to do this is through a data clearing house, in a format that has been internationally agreed on. The format is described by the GSM Association and is referred to as 'Transfer Accounting Procedure' or TAP. The TAP protocol provides standardised procedures and standardised CDR formats so that mobile operators can efficiently exchange CDRs.

Initially, TAP was created for basic GSM services, but at a later stage, resulting in updated versions of the procedure, it was enhanced for data services such as GPRS and UMTS. In this way several versions of TAP are in operation in parallel.
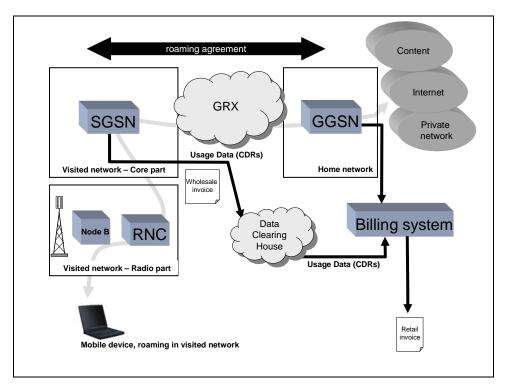
Figure 14 Charging of roaming data services

Most operators apply home roaming, meaning that a data session is routed through the home network to the GGSN. In a roaming data session detail records are available from the home network (GGSN) as well as from the visited network (SSGN through TAP procedure):

▪ It should be noted that TAP procedures (to exchange roaming call details) had already been put in place before data services starting with GPRS were introduced, although these procedures need to be updated for support packet data
▪ The exchange of TAP detail records usually takes place through (commercial) Data Clearing House services. This prevents the mobile operator from having to exchange call detail data with each individual roaming network.

The charging, billing and invoicing process is depicted in Figure 14.

13 Cost components and cost analysis

Based on the description of the network architecture, network elements, and business processes an analysis of the cost components will be executed in this chapter. The cost analysis will focus on incremental cost components in order to identify the cost differences between national data services and roaming data services.

Cost analysis for national data service is not widely explored compared to national voice service. This is the reason to focus on incremental cost components. For national voice service several cost models such as FAC, LRIC have been applied to determine call charges.

It should be noted that the incremental cost analysis will take a different angle on costs than an estimation of Inter Operator Tariffs (IOT). The cost analysis in this chapter will identify and assign costs in the end-to-end data roaming chain in order to analyze incremental cost components for roaming data service.

In the cost analysis the roaming data implementation is based on 'Home roaming'.

13.1 Cost component model

In general, the areas of costs components for data roaming services can be viewed as follows:
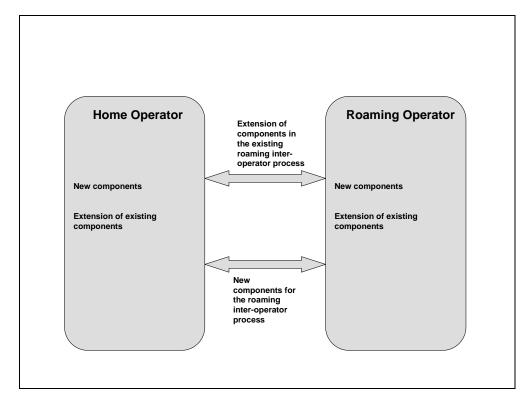

Figure 15 Incremental Cost component model for Roaming Data services compared to National data services.

As is depicted in Figure 15 the areas for cost components for roaming data services are as follows:

1. **Extension of components in existing roaming inter-operator process** These are incremental costs that are incurred due to the roaming data implementation of the components in the existing inter-operator roaming process for voice and SMS roaming.

2. **New components for the roaming inter-operator process** These are costs for new components (systems, processes etc.) due to the roaming data implementation in the existing inter-operator roaming process for voice and SMS roaming.

3. **New components (Home Operator):** These are new cost components (systems, processes etc.) for the home operator.

4. **Extension of existing components (Home Operator):** These are incremental costs for existing components (systems, processes etc.) for the home operator due to the roaming data implementation.

5. **New components (Roaming Operator):** These are new cost components (systems, processes etc.) for the roaming operator (visited operator).

6. **Extension of existing components (Roaming Operator):** These are incremental costs for existing components (systems, processes etc.) for the roaming operator (visited operator) due to the roaming data implementation.

13.2 Cost component mapping

Several components that have been described concerning data roaming service have been mapped into the cost component model that is defined in 13.1. For each of the cost components it has been defined whether the cost is a one-time cost or a recurring cost. The definitions for these types of costs are:

One-time cost

A one-time cost is defined as a (incremental) cost for a cost component that is incurred only at the initial implementation of the data services, and not repeatedly during the operation of the data roaming services.

Recurring cost

A recurring cost is defined as a (incremental) cost for a cost component that is regularly incurred (e.g. monthly or yearly). The cost recurrence may be volume independent (fixed recurring) or the cost recurrence may be data volume dependent so it may vary if traffic changes.

Extension of components in existing roaming inter-operator process		
Component	**One- time**	**Recurring**
Data clearing	●	●
TAP procedures	●	●
Roaming network contracting	●	

	One-time	Recurring
Roaming testing	●	
Roaming roll out	●	
Roaming support	●	●
Roaming Billing Data (wholesale)	●	●

New components in roaming inter-operator process		
Component	One- time	Recurring
GRX	●	●
Additional equipment	●	
Transmission to GRX		●

These costs will exist for the home operator as well as for the visited (roaming) operator. It should be noted that in addition to the cost for using a GRX service there are some extra costs for additional equipment at both ends (Border Gateways, Routers) as well as for additional transmission (from the GPRS network to the GRX point of connection) at both ends.

New components (Home operator)		
Component	One- time	Fixed recurring
-		

Extension of existing components (Home Operator)		
Component	One- time	Fixed recurring
Core network capacity (GGSN)		●
Connectivity to content servers, service platforms etc.		●
Retail billing and invoicing	●	●
Occasional software update and configuration in network elements	●	●
Customer service		●
Network provisioning		●
Fraud and high usage detection		●

New components (Roaming Operator)		
Component	**One- time**	**Fixed recurring**
-		

Extension of existing components (Roaming Operator)		
Component	**One- time**	**Fixed recurring**
Radio network capacity		●
Core network capacity (SGSN)		●
Software update and configuration in network elements	●	●

It should be noted there are no cost increments due to data roaming for SIM/USIM card production and distribution. Also, for common elements in the mobile communication network such as the HLR there are no incremental costs.

13.3 Cost component evaluation

The cost increment analysis will be evaluated taking into account that:

▪ International roaming has already been implemented for (primarily) voice and SMS services. From this perspective several components that are required for data roaming implementation and operation are already available but may need extension or upgrading

▪ National Data services have been implemented in the home network and are available to the users in the home network.

The cost component evaluation will take into account that for certain cost components:

▪ The incremental cost will be regarded as an increment on a per unit basis (in this case incremental cost per data volume)

▪ The incremental cost will be regarded as an additional cost on top of already existing total costs

The first group will be e.g. network elements that have a certain cost per unit of traffic. Increase of traffic will result in increase of network cost, although the cost per unit of traffic does not change compared to cost for national data service. The second group concerns costs that are fixed costs which do not directly depend on traffic volumes.

13.3.1 Cost component evaluation definitions

The definitions of the cost increment estimations are as follows:

Evaluation	Definition
-	Reduction of cost (cost per unit or additional cost) for roaming data services compared to national data services
0	No or minimal incremental cost difference (cost per unit or additional cost) for roaming data services compared to national data services
+	Increase in cost (cost per unit or additional cost) for roaming data services compared to national data services

13.3.2 Extension of components in existing roaming process

Extension of components in existing roaming inter-operator process				
Component	One- time	Recurring	Component for voice roaming?	Component for national data?
Data clearing	●	●	**Yes**	**No**
TAP procedures	●	●	**Yes**	**No**
Roaming network contracting	●		**Yes**	**No**
Roaming testing	●		**Yes**	**No**
Roaming roll out	●		**Yes**	**No**
Roaming support	●	●	**Yes**	**No**
Roaming billing data (wholesale)	●	●	**No**	**No**

These cost components are already implemented and in use for voice roaming. All of these components, in order to introduce data roaming service will need to be extended leading to incremental costs (additional costs) on top of already existing cost for offering national data service.

These costs will exist for the home operator as well as for the visited (roaming) operator.

The incremental cost is further analysed as follows:

Component	Cost evaluation (additional cost)	Remark
Data clearing	+	Compared to already existing data clearing for voice services, data clearing functions have to be extended to support data services (one-time fee). Furthermore, there will be recurrent costs for CDR processing[1]
TAP procedures	+	In general TAP procedures and system implementations will have to be upgraded to support data services (this could mean e.g. upgrade to higher TAP version, processing of Data specific information). This is a one-time cost but there will also be (limited) operational costs involved
Roaming network contracting	+	Existing roaming networks will need to be updated to support roaming data services as well, resulting in additional one-time costs
Roaming testing	+	Additional testing is required per roaming network before the roaming data service may be launched, resulting in additional one-time costs.
Roaming roll out	+	After testing the data roaming service the roaming facilities are to be rolled out all through the network to be operational for the end users, which is a one-time additional cost.
Roaming support	+	There will be (limited) one-time additional costs to update roaming support, as well as (limited) operational support
Roaming billing	+	The serving network needs to charge the home network for using the packet data network. The billing for the serving operator will have to be updated to support roaming data services. This is a one-time cost, although there may be (limited) operational costs.

[1] There are costs for the processing and clearing of CDRs between the roaming network and the home network. The cost per unit is likely to be equal or even slightly lower than for existing data clearing. The reason is that the additional CDRs may be processed in a higher volume-price step resulting in a lower price per CDR overall. Thus the recurring cost may slightly decrease (per CDR) leading to a lower contribution to data roaming cost price increment.

13.3.3 New components in roaming inter-operator process

New components in roaming inter-operator process				
Component	One- time	Recurring	Component for voice roaming?	Component for national data?
GRX	●	●	No	No
Additional equipment	●		No	No
Transmission to GRX		●	No	No

These cost components are new for data roaming implementation and are not used for national data or for voice roaming. In order to introduce data roaming service, all of these components will add costs on top of already existing cost for offering national data service. These costs will exist for the home operator as well as for the visited (roaming) operator. The incremental cost is further analysed as follows:

Component	Cost increment evaluation (additional cost)	Remark
GRX, additional equipment, transmission to GRX	+	For voice roaming services a GRX is not required , but for data roaming this is an additional cost An indication of the recurring cost for GRX for a medium size mobile operator is € 5.000 and €10.000 per month, although this somewhat depends on the data volumes.

It should be noted that other technical solutions than the GRX may be used for the connectivity of the roaming and the home. As for GRX, these solutions are new components and will result in additional cost for implementing roaming data service.

13.3.4 Extension of existing components (Home Operator)

Extension of existing components (Home Operator)				
Component	One- time	Recurring	Component for voice roaming?	Component for national data?
Core network capacity (GGSN)		●	No	Yes
Connectivity to content servers, service platforms etc.		●	No	Yes
Retail billing and invoicing	●	●	Yes	Yes
Software update and configuration in network elements	●	●	No	No
Customer service		●	Yes	Yes
Network provisioning		●	Yes	Yes
Fraud and high usage detection		●	Yes	No

It should be noted that the home radio network and also the SGSN are not used for data roaming and therefore do not contribute to the cost price for data roaming service.

These cost components have already been implemented in the Home network. In order to introduce data roaming service, all of these components will need to be extended, leading to incremental costs on top of already existing cost for offering national data service.

Several of the cost components in this group, however, should be analysed on a per unit basis. Increase of traffic will result in increase of network cost, although the cost per unit of traffic will not necessarily change compared to cost for national data service. The incremental cost is further analysed as follows:

Component	Cost increment evaluation (Cost increment per unit)	Remark
Core packet network (GGSN) home network)	-/0/+	For a mobile operator there is a cost to have sufficient GGSN capacity in the home network in order to support data sessions from roaming networks. For the home network there may be incremental cost (per unit) effects[1]
Connectivity to content servers, service platforms, corporate servers	-/0/+	The connectivity will need to be realised because for voice services this is not required. For the home network there may be incremental (per unit) cost[1]
Network provisioning	0	The network provisioning needs to support PDP Profile activation. However, if national data service has already implemented this, then there is no difference in the cost per unit for provisioning services on the network
Customer service	0	The incremental cost per unit for customer service is expected to be minimal. However, there may be an effect if roaming data customers have different needs (more or less interactions and problems, different level of support etc.) than national data customers. E.g. if customers using roaming data have many networks problems and billing issues and need customer service to solve these then the cost per unit will increase (assuming significant amounts of traffic). There is no evidence that such difference exists, therefore the cost per unit is assumed to be the same for national data as for roaming data users

[1] It should be noted that for additional GGSN capacity as well as for connectivity to content servers, service platforms, and corporate servers etc. capacity in the home network will be required if large amounts of roaming data sessions take place. This of course has a considerable cost, but it is not an incremental cost per data volume with respect to the network capacity for national data services. It should be noted that this is only true if the traffic profiles for the roaming traffic are more or less the same as for national data services. If the international roaming traffic profile is significantly different then there may be some incremental cost per data volume involved. For example, this would be the case if roaming traffic were concentrated in a short period of time (e.g. in one month) and national data were equally distributed over the year.

These seasonal differences could be due to tourist concentrations in certain locations. In those locations there could be overcapacity in the radio network outside the tourist season. This may have a cost (per data volume) increasing effect for the mobile operator. It should be noted that large amounts of data roaming traffic could also reduce the cost per data volume if the total traffic distribution in the radio network has a more constant distribution than national traffic only.

Component	Cost increment evaluation (additional cost)	Remark
Retail billing and invoicing	+	The retail billing system and procedures will need to be enhanced with rating of roaming data usage. This is an additional one-time cost, although there may be (limited) operational costs.
Fraud and High Usage detection	o	For roaming data services fraud can be prevented more effectively since all traffic is flowing though the home network. This is not expected to result in a cost reduction as such.
Software update and configuration in network elements	+	These cost will depend on the supplier for the radio network

Retail Billing and invoicing, and Software Updates and configuration in network elements are implemented in the Home network. In order to introduce data roaming service, this component will need to be extended, leading to incremental costs on top of already existing cost for offering national data service.

Fraud detection and HUR is not expected to be a relevant cost component because of the widely applied home routing solution for data roaming.

13.3.5   Extension of existing components (Roaming Operator)

New components (Roaming Operator)				
Component	One- time	Recurring	Component for voice roaming?	Component for national data?
Radio network capacity		●	No	Yes
Core network capacity (SGSN)		●	No	Yes
Software update and configuration in network elements	●	●	No	No

Radio network capacity and core network capacity in this group should be analysed on a per unit basis. Increase of traffic will result in increase of network cost, although the cost per unit of

traffic will not necessarily change compared to cost for national data service. The incremental cost is further analysed as follows:

Component	Cost increment evaluation (Cost increment per unit)	Remark
Radio network (visited network)	-/0/+	For the visited network there may be incremental cost (per unit) effects[1]
Core packet network (SGSN, visited network)	-/0/+	For a mobile operator there is a cost for having SGSN capacity in the visited network in order to support data sessions in roaming networks. For the home network there may be incremental cost (per unit) effects[1]

[1] It should be noted that additional radio network capacity in the visited network will be required if large amounts of roaming data sessions take place. This of course has a considerable cost, but it is not an incremental cost per data volume with respect to the network capacity for national data services. It should be noted that this is only true if the traffic profiles for the roaming traffic are more or less the same as for national data services. If the international roaming traffic profile is significantly different then there may be some incremental cost per data volume involved. For example, this would be the case if roaming traffic were concentrated in a short period of time (e.g. in one month) and national data were evenly distributed over the year. These seasonal differences could be due to tourist concentrations in certain locations. In those locations there could be overcapacity in the radio network outside the tourist season. This may have a cost (per data volume) increasing effect for the mobile operator. It should be noted that large amounts of data roaming traffic could also reduce the cost per data volume if the total traffic distribution in the radio network has a more constant distribution than national traffic only.

The cost increasing/decreasing effects are expected to be low if they exist at all, since the traffic profiles for national and roaming data services are not expected to show large differences other than seasonal influences.

It should be noted that for additional SGSN capacity a similar situation exists as for the incremental cost for the radio network capacity.

Component	Cost increment evaluation (additional cost)	Remark
Software update and configuration in network elements	+	These cost will depend on the supplier for the radio network

Software Updates and configuration in network elements are implemented in the Roaming network. In order to introduce data roaming service, this component will need to be extended, leading to incremental costs on top of already existing cost for offering national data service.

13.4 Cost variation analysis

The level of incremental costs may vary depending on several parameters. Some of these parameters are:

- Size of the mobile operator

- Volume of data

Size of the Mobile operator

It could be expected that the total one-time incremental cost for data roaming implementation will only slightly vary with the size of a mobile operator. The amount of implementation activities to be executed is primarily determined by the amount of roaming partner networks and to a lesser extent by the size of operator. Therefore, small operators and large operators more or less have to execute similar activities and have to bear more or less similar cost levels.

At relatively low data roaming volumes (as is currently the case) small operators may have the disadvantage in bearing these one-time incremental costs. At small data volumes large operators should be able to benefit from their economy of scale and be able to offer lower data roaming rates than small operators.

Higher Volume of Data

If the data volume is increased significantly (e.g. by a factor 10) compared to current roaming data volumes the incremental cost per volume is expected to decrease significantly. This will be caused by the fact that the recurring costs will show a limited disproportional increase for an increase of data volume, and one-time recurring can be recovered from a larger data volume. This effect will be apparent for small as well as for large operators. For large operators in particular it may be expected that at certain data volumes the impact of one-time costs is reduced and that the data roaming rates will primarily be determined by the incremental recurring costs on top of the national data rates.

13.5 Cost analysis

From the perspective of the home operator, the cost components used for providing national data service are also used for providing roaming data service. The main difference between national and roaming data is that some of the components (e.g. the radio network and the SGSN) for data roaming are used in the visited network instead of in the home network.

It should be noted that additional radio or core network capacity is required if large amounts of roaming data sessions take place. This, of course, has a considerable cost, but it does not necessarily lead to costs different than adding radio or core network capacity for national data services. When using these similar components as for a national data service, a cost increment in the cost price for data service can be justified if:

- Traffic profiles for the roaming traffic differ from the traffic profile for national data services. For example there may be seasonal differences due to tourist concentrations in certain locations. In those locations there could be overcapacity in the radio network outside the tourist season. This may have a cost increasing effect for the mobile operator.

- The unit costs for the components explored from the visited network are different from the unit costs for these components in the home network. This could be caused by a difference in supplier, technology, or traffic volume.

These differences in cost could contribute to a difference in the Inter Operator Tariff (IOT) that the home network has to pay for. If the IOT were higher this could lead to a higher retail price for the roaming data service.

Besides the fact that for roaming data service similar cost components are applied for providing the service, there are several additional costs involved when enabling data roaming on top of the voice roaming service implementation. These costs are:

- One-time costs in the home components to enable data roaming.

- One-time costs for changes in existing roaming processes and components

- One-time costs for new roaming processes and components needed for data roaming

- Recurring costs in existing and new roaming processes and components

The new component needed to enable data roaming is the GRX service. The cost for GRX-service is expected to be between € 5.000 and € 10.000 per month, depending on the size of the operator, and the total data volume for roaming. In mapping cost components it is concluded that there is a limited number of new components with respect to the already existing voice roaming service.

In general, the total one-time costs are not expected to be substantially different for small or large operators. This is also expected to apply to some of the recurring costs.

Over time when data volumes will be increasing, the cost per traffic unit may be expected to decrease significantly, since total cost increments are only partly volume dependent. Recurring cost increments are expected to increase proportionally but at a low rate. Verification of this expectation needs further study.

The cost price per unit of traffic for the additional components (compared to a national data needed) to provide data roaming service is highly depending on the volume.

Currently, at low data volumes, incremental cost levels for roaming data are expected to be determined primarily by one-time implementation costs for data roaming services.

In a low data volume scenario, the cost price per unit of traffic may be substantial compared to national data. This could justify an increment for the retail rates of data roaming compared to the national data rates. It should be noted that such an approach could limit the future growth of data roaming volumes.

In a high data volume scenario (for large operators and/or at substantial market growth) and after depreciation of the one-time costs for data roaming implementation, the cost price is expected to be substantially lower than the current cost price for roaming data. Verification of this expectation needs further study.

Small operators may have a relatively high incremental cost, caused by low data volumes and by having one-time incremental costs that are nearly equal to those of large operators. Even at higher data volumes small operators may have difficulty in reaching the same incremental cost levels as large mobile operators. This may be an indication that in cost analysis and cost price evaluation the difference between large and small operators should be carefully evaluated.

The incremental cost for data roaming depends on several parameters such as data volume, operator size, but also cost assumptions, cost assignment rules, and traffic inbound-outbound rates etc. A wide cost range may be apparent in practice, meaning that an average cost fit may be difficult to determine.

Determination of the actual levels of the cost increments in the various situations for different operator scenarios will require further study in order to gain sufficient insight into:

- The cost price and cost model for national data services
- The relation between retail price and cost price for the data services

14 Conclusions

14.1 General

HSPA is clearly making the difference for the mobile industry in enabling the launch of mobile data services and meeting business targets. HSPA has evoked a significant improvement in data rates, an improvement in spectral efficiency and shorter delay time (latency) for data transfer. Currently mobile operators in Europe commonly apply GPRS, EDGE, UMTS and HSPA technology to offer packet data services.

Most operators, if not all, have decided on a 'home roaming' implementation of data services, meaning that both the visited and the home network are required for a roaming data session.

The bearer technology for packet switched networks such as HSPA is used for different data services. This distinguishes data services from voice and SMS, in which there is basically one service to one bearer technology.

For mobile data services, the mobile industry distinguishes 2 concepts: the 'managed' and the 'unmanaged' model. In the 'managed' model, services are offered as a complete service to the customer in which basic infrastructure, service specific infrastructure (like, for instance, the MMS platform), software, quality of service, devices and price plans are combined in an integrated offer to the customer. The mobile operator then has 'full customer ownership' meaning that the mobile operator invoices for both the internet access and for the service provided.

The various data services offered in the 'managed' model on the packet switched bearer technology may be priced differently. Data traffic can vary in price depending on the service it is used for. In general, services that require high data volumes have a lower average price per MB. When regulating data services it is important to realise that currently there is no single price per MB offered to the retail customer.

14.2 Domestic market for mobile data communication

The national mobile data market has certain characteristics that caused operators to move to an aggressive price approach on mobile data services.

Taking into account the concept of the 'managed' model, the principle of service based pricing and the market situation, several trends in retail data pricing can be distinguished. Basic mobile access to the internet is offered by some operators at aggressive rates competing with fixed ADSL offers. In the largest data volume bundles the price per MB can be below € 0,01 per MB providing that the total bundle is consumed. In addition to this general downward trend of the price per MB there is also a strong differentiation in prices per MB for the various data services. National data services are usually offered in a bundle with a monthly fee.

It remains to be seen if some of the current offers, judging from a cost perspective, are sustainable in the long run. Current retail offers do not necessarily reflect historic and/or future cost levels for mobile data networks. This means that current retail data charges might – from a cost perspective - not be the right level to benchmark against wholesale and retail roaming charges.

14.3 Wholesale roaming

In Europe, the average standard IOT for data roaming ranges is estimated to range for most operators between € 5,00 and € 10,00 per MB. There are 2 models for the Inter Operator Tariff for data usage:

- Flat rate per MB combined with billing increments

- 'Step based' pricing per MB.

Up until 2007, the negotiated IOT was usually a flat rate per MB, billed per KB. In general, there is no differentiation between services or data volumes (as is made for data offers in the retail market) in the IOT. In this sense, the wholesale roaming negotiations are not 'connected' to the recent developments within the retail market of national mobile data usage. Between preferred partners the level of the negotiated IOT is estimated (for 2007) to be between € 0,50 and € 1,00 per MB. Within a group of operators, the rates between the group members do not necessarily have to be at these levels.

Traffic steering for data traffic can be less effective than for voice traffic. Steering has been implemented by mobile operators primarily from a voice perspective in order to reduce wholesale (roaming) costs, improve margins, or optimize roaming retail rates. For data services some new challenges are apparent for steering of roaming. The preferred network for voice roaming is not necessarily the preferred network for data roaming if this data network has an incompatible technology, does not offer the appropriate Quality of Service (e.g. if UMTS or HSDPA are not available to the roamer), or has unattractive roaming retail rates. As a result, if steering of roaming is voice-driven, a handset (laptop, blackberry, PDA) may be steered to a wrong network.

The above leads to a situation in which on average the negotiated IOT in the European region is estimated (for 2007) to be between € 2,50 and € 5,00 per MB. This might differ substantially per operator (depending on traffic patterns) and per country.

IOT negotiations for data services with non-preferred partners are of importance for some operators because of the high difference in rates between preferred and non-preferred partners and because of the potentially lower traffic steering efficiency. With non-preferred partners it may be difficult to agree on a low IOT for data. Small operators and groups whose preferred partners do not offer HSPA or sufficient UMTS coverage might especially be confronted with this situation.

As of 2008, some operators and/or groups have moved to a net IOT, based on the 'step price' model in which there are different volume/price bands for a data session. This can be combined with billing increments. This enables the home operator to offer attractive retail rates for larger data sessions. At the same time this decreases the profitability for the home operator of the data sessions with small data volumes.

14.4 Cost perspective

From the perspective of the home operator, the cost components used for providing national data service are also used for providing roaming data service. The main difference between national and roaming data is that some of the components (e.g. the radio network and the SGSN) for data roaming are used in the visited network instead of in the home network.

It should be noted that additional radio or core network capacity is required if large amounts of roaming data sessions take place. This, of course, has a considerable cost, but it does not necessarily lead to costs different than those for adding radio or core network capacity for

national data services. When using these similar components as for a national data service, a cost increment in the cost price for data service can be justified if:

- Traffic profiles for the roaming traffic differ from the traffic profile for national data services. For example, there may be seasonal differences due to tourist concentrations in certain locations. In those locations there could be overcapacity in the radio network outside the tourist season. This may have a cost increasing effect for the mobile operator.

- The unit costs for the components explored from the visited network are different from the unit costs for these components in the home network. This could be caused by a difference in supplier, technology, or traffic volume.

These differences in cost could contribute to a difference in the Inter Operator Tariff (IOT) that the home network has to pay for. If the IOT were higher this could lead to a higher retail price for the roaming data service.

Besides the fact that for roaming data service similar cost components are explored for providing the service, there are additional costs involved to enable data roaming on top of the voice roaming service. These costs concern:

- One-time costs in the home components to enable data roaming.

- One-time costs for changes in existing roaming processes and components

- One-time cost for new roaming processes and components needed for data roaming

- Recurring costs in existing and new roaming processes and components

The new component needed to enable data roaming is the GRX service. The cost for GRX-service is expected to be between € 5.000 and € 10.000 per month, depending on the size of the operator. In mapping cost components it is concluded that there is a limited number of new components with respect to the already existing voice roaming service.

In general, the total one-time costs are not expected to be substantially different for small or large operators. This is also expected to apply to some of the recurring costs.

Over time when data volumes will be increasing, the cost per traffic unit may be expected to decrease significantly, since total cost increments are only partly volume dependent. Recurring cost increments are expected to increase proportionally but at a low rate. Verification of this expectation needs further study.

The cost price per unit of traffic for the additional components (compared to national data needed) to provide data roaming service highly depends on the volume.

Currently, at low data volumes, incremental cost levels for roaming data are expected to be determined primarily by one-time implementation costs for data roaming services.

In a low data volume scenario, the cost price per unit of traffic may be substantial compared to national data. This could justify an increment for the retail rates of data roaming compared to the national data rates. It needs to be noted that such an approach can also limit the future growth of data roaming volumes.

In a high data volume scenario (for large operators and/or at substantial market growth) and after depreciation of the one-time costs for data roaming implementation, the cost price is expected to be substantially lower than the current cost price for roaming data.. Verification of this expectation needs further study.

Small operators may have a relatively high incremental cost, caused by low data volumes and by them having one-time incremental costs that are nearly equal to those of large operators. Even at higher data volumes small operators may have difficulty in reaching the same incremental cost levels as large mobile operators.

Determination of the actual levels of the cost increments in the various situations for different operator scenarios will require further study.

When evaluating these cost levels, it is important to be aware that cost is only one of the factors that operators consider when constructing a retail data offer. Elements like packaging, segmentation, transparency, service based pricing, and the market situation might prove to be more important drivers at this stage of the market development than cost alone.

14.5 Translating wholesale data rates into retail data roaming offers

From the home operator perspective, the wholesale cost charged by the visited operator via the IOT is one of the most important factors that determine the possibility for the home operator to construct an attractive data roaming offer.

With retail prices for national data traffic (for the service of basic web access) going to levels of a couple of eurocents per MB (or even below) combined with an average discounted wholesale roaming charge between € 2,50 and € 5,00 it is difficult for some operators to bring attractive retail data roaming prices to the market for high volume data services like e.g. web access.

In particular for small operators or small operator groups in a net paying position this will be difficult because they have limited possibilities to negotiate data roaming rates and/or 'internalize' wholesale charges. For large operator groups with a large footprint in all major destinations, and operators providing HSPA, the wholesale charges will be less of an issue in constructing attractive retail data roaming offers. When wholesale charges are 'internalised' group members will only have to take into account the actual cost involved in data roaming and they will be able to offer data roaming services at levels closer to the national data rates. Although groups have these possibilities, because of cost involved in setting up data roaming, competition and/or value offered to the customer, data roaming is not automatically offered at rates close to national rates. The model most often seen for retail data roaming charges is a price per MB combined with billing increments. The average retail charge in the EC is € 5,24 per MB (source ERG data). In some cases, the rates are different per segments or per service.

Many operators are now moving to offer monthly or daily bundles of roaming data volumes. For the monthly bundles the retail data roaming price moves to levels below € 1,00 per MB, whereas for non-bundle usage the rates typically range between € 5,00 and € 10,00 per MB. In daily bundles some operators even offer rates of € 0,24 per MB if the bundle is fully consumed.

As concluded above, it is difficult for some operators to construct attractive data roaming offers for services that require high data volumes. Since customers are often not aware of the price plan for data roaming and of the data usage abroad, they may be unpleasantly surprised when returning home and receiving their bill. This has caused customers to be very cautious about data roaming. This is one of the reasons for low data roaming volumes so far.

Mobile operators consider the market situation with high cost for large volume data sessions a problem. Customers are not satisfied and volumes and revenues are low. Many operators are moving in the direction of:

- An increased focus on data roaming negotiations reaching for lower wholesale rates, with both preferred and non-preferred partners, service and volume differentiation ('step-price' model) in the wholesale prices. In addition to this mobile operators need to relate these ambitions for wholesale charges to the future data cost levels for national and roaming usage.

- The introduction of new and improved retail offers. Knowing that current data roaming volumes are low, it is likely (however not necessarily)-that operators will improve the retail offers for high volume sessions in order to generate more revenues. The 'business case' for such an approach can be very positive. The situation for data roaming might in this respect be different from that for voice roaming.

In addition to the initiatives on wholesale and retail rates, there is a need for information to be given to customers about both their retail price plans for data roaming and the data volumes consumed (preferably on a near real-time basis) when abroad. Because of limited end user knowledge and awareness, the difference between expected data volumes and actual data volumes and because of the principles of data charging, the customer may be surprised by expensive data roaming bills.

14.6 Challenges when regulating data roaming services

When considering data roaming regulation it is important to keep the following in mind. There is no single price per MB. This differs per service being offered. This means:

- Since roaming prices can not be seen in isolation, regulation at default price per MB can affect the business model that operators use. This is not only the case for roaming services, but also for national data services.

- Regulating data roaming can have an impact on voice roaming. This is because voice calls can be handled -via VoIP technology- on the packet switched network.. A minute of voice now equals a certain data volume. The amount of data being used for a voice call is dependent on the compression technology being used. This can develop over time.

The market issues for data roaming are:

- High and unexpected bills while roaming

- Limited usage of the service because of high rates compared to national data usage

The issue is mainly related to services generating high volumes in a limited time period. For services like for instance Blackberry this does not seem to be the case.

Price regulation alone will not solve all market issues in a situation when customers are not aware of data volumes consumed while roaming and are not aware of the price plan they are in (including the billing increments used and the number of data sessions the service generates). A service like streaming video while roaming in a model of data volume charging would remain expensive even if retail roaming rates had substantially decreased.

Current retail data prices do not necessarily reflect future cost levels. This means:

- Current retail data rates might – from a cost perspective- not be the right benchmark when considering regulation of data roaming rates

- Some operators might be in a different position (from a cost perspective) because of the underlying technology being used, because of the level of utilization of the network and because of the data roaming volumes

Small operators and groups might be in a different position than large operators and groups when negotiating wholesale rates with preferred and non-preferred partners and in translating these into an attractive retail data roaming offer.

Currently, the underlying data roaming wholesale rates limit some operators in bringing attractive offers towards the market for services generating high volumes. When wholesale rates have improved it is likely that retail roaming rates for high volumes data sessions will be more in line with national data usage rates. This assumes that there is an incentive for operators to pass through the benefits of lower wholesale rates to their customers, in the hope of increasing traffic volumes. This might prove a sound business case for a mobile operator. For voice services, the market showed a situation of decreasing wholesale rates combined with relatively high retail rates. This has led the Commission to propose regulation of both wholesale voice rates and retail voice rates. For data, the current situation for high volume data sessions can be characterised as 'high wholesale rates combined with high retail roaming rates'.

For voice roaming there are almost no alternatives available. This is mainly because the customer needs to be reachable at the mobile phone number.

For data roaming the customer has alternatives to choose from:

- Customers who make frequent use of data roaming services can subscribe to an alternative mobile network if their provider for voice services does not provide an attractive data roaming offer. This could even be a foreign mobile provider.

- Wi-Fi services. The use of data services (in particular for a laptop computer user) is often of a static nature; this means the customer is at a certain location and does not use it 'on the move'. Wi-Fi offers coverage in major airports, hotels, conference centres etc. The speed of Wi-Fi is comparable to ADSL and the costs are relatively low and usually volume independent. Rates for Wi-Fi typically vary between € 5, 00 and € 10, 00 for a 1 hour usage and between € 10,00 and € 20,00 for a full day usage. Some Wi-Fi providers (e.g. in hotels or cafés) might decide to offer Wi-Fi for free in order to attract customers. Wi-Fi usually does not have data volume limitations.

Setting a price level for regulation of data roaming services may not be easy when considered from a cost perspective. First because there has been little experience with data cost models and cost calculations and secondly because of the relative small current volumes and of the potential cost differences between different operators.

Appendix I

This section describes standardization effort from the European perspective, as well as for the rest of the world.

Europe

In the European Union the majority of mobile network operators apply network technology that is based on the standardization of the Third Generation Partnership Project (3GPP). This standardization comprises Enhanced Data rates for Global Evolution (EDGE), Universal Mobile Telecommunication Services (UMTS), and High Speed Data Access (HSPA) etc.

As is shown the standards UMTS and HSPA were built on WCDMA radio access technology. Parts of the frequency spectrum for WCDMA in the 1885-2025 MHz (uplink) and 2110-2200 MHz (downlink) band have been licensed to mobile communication operators all through Europe since 2000. UMTS and HSPA enable data services that make use of the concept of packet switching.

Initially, the GSM standardization did not enable sufficient Packet Switching functions. Packet Data was then introduced into GSM systems by using General Packet Radio Services (GPRS) as an overlay to existing GSM networks using the same radio access network. GSM and GPRS standardization had been executed by the European Telecommunication Standardization Institute (ETSI). Prior to GPRS, circuit switching techniques such as GSM Data and HSCSD were developed to enable data services in GSM networks. GPRS, generally referred to as 2.5G, was an obvious migration step for GSM operators to full 3G operation.

ETSI also worked on Enhanced Data rates for Global Evolution (EDGE). EDGE, using the GSM spectrum, boosts the GSM/GPRS capacity and bit rates over the radio air interface by introducing more advanced coding schemes. EDGE was transferred from ETSI to 3GPP in 2000. 3GPP standardised the UMTS technology applying the harmonised Japanese/European WCDMA access technology. WCDMA is now one of the globally standardised (3G) radio systems for mobile communication.

UMTS/WCDMA radio access evolved into High Speed Packet Access (HSPA) that consists of High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA).

The frequency spectrum for WCDMA allows for TDD and FDD modes. Frequency Division Duplex (FDD) operates separate (paired) frequencies for uplink and downlink communication. In the Time Division Duplex (TDD) mode uplink and downlink are operated in the same frequency using TD-CDMA. The TDD mode is not widely used.

FDD is the widely used mode for UMTS using WCDMA and applies paired frequencies in the 1920-1980 MHz and 2110-2170 MHz.

Rest of World

Although the GSM driven roadmap towards UMTS and HSPA is adopted outside of Europe in many parts of the world, there are also other roadmaps applying different radio network technologies.

A parallel (to 3GPP) standardization body 3GPP2 was founded in 1998 and focused on CDMA2000, as an alternative radio access scheme to WCDMA. North America has been the key driver for this. Similar to the evolutions in 3GPP to HSPA, CDMA2000 evolved into EV-DV

(Evolution for Data and Voice) and EV-DO (Evolution for Data only). CDMA2000 is largely used in the United States and in some other parts of the world, but not in Europe in any of the EC countries, therefore CDMA 2000, EV-DV and EV-DO are not part of the scope of this study. It should be noted that several mobile operators in the United States, however, are now opting for GSM driven technology.

Global Standardization

The global 3G standardization currently consists of WCDMA, CDMA2000, EDGE as well as TD-CDMA and TD-SCDMA. All these access methods make use of Code Division Multiple Access (CDMA) principles.

TD-SCDMA is the standardization that was developed in China. Recently (2007), also WiMAX was listed as a 3G radio access interface.

Glossary

3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project
AA12	Addendum document in roaming agreement
AA13	Addendum document in roaming agreement
AA14	Addendum document in roaming agreement
ADSL	Asynchronous Digital Subscriber Line
APN	Access Point Name
ATM	Asynchronous Transfer Mode
BSC	Base station controller
BTS	Base Transceiver Stations
CDMA2000	Code Division Multiple Access, Name for 3G radio system
CDR	Call Detail Record
CDMA	Code Division Multiple Access
EDGE	Enhanced Data rates for Global Evolution
ERG	European regulators Group
EV-DV	Evolution for Data and Voice
EV-DO	Evolution for Data only
EU	European Union
FDD	Frequency Division Duplex
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GPRS	Roaming Exchange (GRX)
GSM	Global System for Mobile Communication
GSMA	GSM Association
HLR	Home Location Register
HSCSD	High Speed Circuit Switched Data
HSDPA	High Speed Downlink Packet Access
HSOPA	High Speed OFDMA Packet Access
HSPA	High Speed Data Access
HSPA+	evolved HSPA

HSUPA	High Speed Uplink Packet Access
IEEE802.11a	Standardization of Wireless LAN (or Wi-Fi) version a
IEEE802.11g	Standardization of Wireless LAN (or Wi-Fi) version g
IEEE802.16	Standardization of WiMAX
IOT	Inter Operator Tariff
IPX	Internetwork Packet Exchange
IMS	IP Multimedia Subsystem
ITU	International Telecommunication Union
IMSI	International Mobile Subscriber Identity
IP	Internet Protocol
IR21	Document part of roaming agreement containing network details
ISP	Internet Service Provider
JPEG	Joint Photographic Expert Group (compression method for still pictures)
KB	Kilobyte
Kbps	Kilobits per second
LAN	Local Area Networks
LTE	Long Term Evolution
MB	Megabyte
Mbps	Megabits per second
MIMO	Multiple Input Multiple Output
MP3	MPEG-1 Layer 3, a coding method to compress audio
MPEG	Moving Pictures Expert Group
MMS	Mobile Multimedia Service
MVNO	Mobile Virtual Network Operators
MSISDN	Mobile Subscriber ISDN
NRA	National Regulatory Authority
OFDMA	Orthogonal Frequency Division Multiplexing Access
OTA	Over The Air
QoS	Quality of Service
PDA	Personal Digital Assistant
PDP	Packet Data Profile
PSTN	Public Switched Telephony Networks
RNC	Radio Network Controller

SMS	Short Message Service
SoR	Steering of Roaming
SGSN	Serving GPRS Support Node
SIM	Subscriber Identification Module
TAP	Transfer Account Procedure
TDD	Time Division Duplex
TD-CDMA	Time Division Code Division Multiple Access
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
UMA	Unified Mobile Access
UMTS	Universal Mobile Telecommunication system
USIM	UMTS Subscriber Identity Module
VoIP	Voice over IP
WAP	Wireless Access Protocol
WCDMA	Wideband Code Division Multiple Access
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access